AN ACCOUNT OF OPERATIONS IN THE HARVARD FOREST, 1908–09

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The operations here described constitute the first year's cut from the Harvard Forest. They were carried out between December and March, 1908–09. At the outset, pending the completion of the working plan, the amount of the cut was determined partly by a rough measurement of the growing stock and estimate of the growth, and partly by silvicultural condition, salability, and considerations of local policy. It was decided to cut about 200,000 feet of lumber (which was well within the annual increment from the tract), and 200 cords of firewood. In planning the operation, a permanent site was chosen for a portable mill, to which all logs over an area of 150 acres could be hauled down hill. In this way the woods work and the saw-mill work could be kept entirely separate. The intention was to do just as much improvement cutting, yielding an inferior grade of lumber, as was consistent with securing a fair price for the main cut of mature timber. Three adjacent areas were taken in hand, all lying on a gentle to fairly steep westerly slope and distant between one-half and three-quarters of a mile from the mill-yard. All saw timber, both good and poor, was piled together in the mill-yard, where, at the end of the winter's work, it was sold in the log. The cord-wood was sold as it lay after cutting. The hauling both of wood and logs was done either with the wooden scoot or jumper, or the iron-shod two-sled, according to the nature of the ground surface and the condition of the going. The chopping was contracted for wholly by the cord and by the thousand feet. Thus it was possible to have the trees taken out in thinnings cut for the same price as those which were cut clean; and to a lesser degree the same plan was followed with the cord-wood.

Following are descriptions of the forest conditions and the nature of the treatment for each of the three compartments: —

Compartment 1*a*. Quality II. — The forest on Compartment 1*a* consisted of a dense, even-aged stand of white pine, with about 10% by area of red maple, black birch, red oak, and poplar, occurring principally in small groups. The average age was 60 years, and the stand per acre amounted to approximately 40,000 feet board measure. The condition of the crop was poor, the trees having stood much too dense. The growth for the past 20 years had been extremely slow, and though the crowns of the trees were abnormally short, there was scarcely any clear length, and a considerable amount of red rot (Tramites pini) had begun to appear, chiefly among the over-topped and suppressed trees. There was very little ground-cover, except needles and a thin humus, but throughout most of the compartment a partial reproduction of hardwood seedlings, chiefly white ash, sugar maple, black cherry, red oak, and chestnut, had already started. In view of these conditions a thinning was determined upon, with the expectation that, as the autumn of 1908 was a heavy seed year, the reproduction of pine might be started, and that the increment of the remaining trees would be stimulated. This thinning was to constitute a combination of preparatory and seed cutting under a Shelter-wood System with Uniform Cuttings. It included all over-topped and suppressed pines, a good many of the intermediate, and such dominant trees as were in poor condition, or excessively wide-crowned. At the same time the scattered hardwoods were all cut, except where their removal would leave too large an opening. Owing to the density of the stand, the amount of slash and tops left after cutting was very small, and when the pine cord-wood was taken out of it, what remained was not sufficient either to hinder reproduction or to constitute a serious risk from fire. (See illustrations of Compartment 1*a*.)

In the autumn of 1909, when one growing season had passed, the area was examined for results of the reproduction. Pine seedlings were found to have come in abundantly almost all over the cutting. In a series of counts taken on plots 8 feet square, the lowest number was 16 and the highest was 65. In color and

COMPARTMENT 1*a*. — Pure White Pine 60 years old. Upper picture before, lower picture after, first cutting under the Stand Method.

condition the plants were slightly less healthy than the normal, owing mainly to the bed of needles through which the rootlets were not easily able to reach the mineral soil, and in part to the reduced light.

In spite of the prevailing drought, this reproduction survived the summer of 1910 with increasing vigor, and at the present writing, the end of May, 1911, the season's shoots have already grown from one to two inches. Considering only density and health, the new crop is already effectively established. The effect of removing the old stand, with the attendant damage and increase of light, has yet to be demonstrated.

Compartment 1*b*. Quality II. — This compartment was covered with an irregular stand of mixed hardwoods representing the gradual extension of a temporary type over land which fifty years ago was partly pasture. Thus the stand was made up of small areas of fairly dense and even pole-and-sapling growth, and other areas where scattered, large wolf trees stood over thickets of valuable seedling and sapling growth. The species represented were chiefly red maple, large-toothed poplar, gray and paper birch, chestnut, red oak, and hard maple, with scattering white pine. Almost everywhere there was an excellent reproduction of valuable hardwoods and white pine, some of it already in the sapling stage. The treatment applied here consisted of improvement cuttings for the utilization of the deteriorating, mature trees, and the release and stimulation of young growth. The groups of dense, half-grown hardwoods were thinned, the scattered, old hardwoods were cut, and the poplar, which was, most of it, a little past maturity, was culled over the compartment. This treatment involved in some places such a very heavy cut that a considerable proportion of the young growth was unavoidably damaged, but for all that, enough to justify the operation was saved, and even that injured was left in condition to sprout again. The slash, which was mainly of poplar and red maple, was left scattered on the ground. (See illustrations of Compartment 1*b*.)

Compartment 2. Quality I. — The stand here was a dense mixed forest of white pine and hardwood, 60 years old, and ranging in height from 80 to 90 feet. Seventy-five per cent was pine,

COMPARTMENT 1*b*. — Upper picture before, lower picture after cutting

and the rest chestnut, black cherry, red oak, white ash, and black birch. As a whole it was mature, and a small amount of red rot had appeared. The leaf litter was 3″ to 6″ in depth, and the humus 2″ to 4″. There was already a large reproduction of well-distributed hardwood seedlings on the ground, of which white ash, black cherry, red oak, and chestnut were the chief species. Moreover, these seedlings were for the most part less than a foot high, and consequently not likely to be seriously injured in the logging. Reproduction of pine was practically wanting, as is usually the case in such heavy, dark stands, but the autumn of 1908, as already stated, was marked by a very heavy fall of pine seed. It was therefore expected that by cutting the stand clear, and burning the heaviest of the slash, a reproduction of mixed pine and hardwoods would be secured. Such a mixture is without question the most valuable and productive for good situations, both in the quantity of wood produced, and in the quality of the timber. The certainty of the reproduction, of course, cannot be guaranteed, but in many cases, where a similar operation has coincided with a seed year, a satisfactory new crop has followed, even without any attempt to dispose of slash. In any event, from one-third to one-half of a full stocking will be furnished by the hardwood reproduction, and in case of a failure of the pine, seedlings can be very cheaply planted next the stumps of the old trees, thereby securing a favorable spot for growth, and partial freedom from possible suppression by hardwood sprouts.

The results of this clear cutting were as successful as the unfavorable growing season of 1909 would lead one to expect. By the end of June a count showed from two to a dozen exceptionally thrifty white pine seedlings to the plot of 8 feet square. The rest of the summer was abnormally dry, and by autumn nearly half of the seedlings had dried out and died. Those still living, many of which had made remarkable growth, were situated either where the leaf litter and humus had been well mixed with the mineral soil, in small moist depressions, or where there had been side shade from weeds or the adjacent woods during the hot part of the day. The plants which had died had stood chiefly on the south side of small hummocks or where the thick mat of

needles and humus had not been disturbed. In ordinary seasons a sufficient number of seedlings to restock the ground would probably have survived.

Although this method of natural reproduction by clear cutting may fairly be called uncertain, a good case can none the less be made out for it. *First*, it involves the lowest possible cost of operation. *Second*, the necessary burning of slash makes for protection, and is (certainly in part, if not entirely) chargeable to that account, and to the cost of formation of the new

COMPARTMENT 2. White Pine and Hardwoods 60 years old, with abundant hardwood reproduction

crop. *Third*, the form of the stand and the mixed crop with which it is to be replaced make any method by partial cutting almost impracticable. If scattered seed trees from such a dense tall forest are left, they are very apt to blow down, and before they have finished seeding up the ground, the hardwood reproduction has got too great a start. Group or Shelter-wood cuttings tend unduly to increase the percentage of hardwoods, and Selection cutting is still more unsuited to the silvics of the

desirable species, pine and chestnut. On the other hand, when such a forest as this is cut down immediately after a fall of seed, from one half to a full stocking for the ground is assured, supplementary planting (if needful) is cheaply done, and the resulting combined crop begins effective growth almost at once.

A summary of the financial aspect of these three operations is given in the following table: —

YIELD, COSTS, AND RECEIPTS. — OPERATIONS 1908–09

Location	Area Acres	Product	Yield		Costs per Unit Volume				Total Costs per Unit Volume	Selling Price		Net Return	
			Per Acre	Total	Chopping	Skidding	Yarding	Disposal Brush		Basis	Amount	Per unit Volume	Total
Compartment 1a	6.5	Pine Box Boards .	6150 B.M.	40,000 B.M.	$1.00	. .	$3.56	. .	$4.56	Log	$11 25	$6.69	$267.60
		Hardwood Cord-wood	4 cds. 2 ft.	27 cds. 7 ft.	.90	. .	. .	. .	.90	Cut	2.00	1.10	30.68
		Pine Cord-wood .	2 " 4 "	16 "	.90	. .	. .	. .	.90	"	1.25	.35	5.60
Compartment 1a	16.7	Poplar Box Boards	1900 B.M.	33,000 B.M.	1.00	$2.50	1.53	. .	5.03	Log	11.25	6.22	205.26
	3.3	Birch and Maple Cord-wood . .	10 cds. 4 ft.	35 cds. 1 ft.	.90	. .	. .	. .	.90	Cut	2.00	1.10	38.64
	16.7	Poplar Cord-wood	1 " 6 "	29 "	.90	. .	. .	. .	.90	"	1.25	.35	10.15
Compartment 2	3.75	Pine, 30 % Box Boards	38,400 B.M.	144,000 B.M.	1.00	. .	1.77	$0.30	3.07	Log	11.25	8.18	1177.92
		Hardwood Cord-wood	22 cds. 1 ft.	83 cds.	.90	. .	. .	. .	.90	Cut	2.00	1.10	91.30
		Pine Cord-wood .	7 " 2 "	27 " 4 ft.	.90	. .	. .	. .	.90	"	1.00	.10	2.75

TREES AND OTHER WOODY PLANTS FOUND IN THE HARVARD FOREST, PETERSHAM, MASSACHUSETTS

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The following enumeration of the trees and other ligneous plants found growing naturally or naturalized in the Harvard Forest or proximity, in Petersham, Massachusetts, is issued primarily as a reference or hand list for the convenience of students in the Harvard Forest School.

As the forest has not been thoroughly examined in the short period since it was acquired, other species will undoubtedly be found, so that the present list may be regarded as a provisional one.

Since the line between herbaceous and ligneous or shrubby plants cannot be sharply drawn and is a purely arbitrary matter, some plants may be found in this list which would be left out by some dendrologists, while consistency might compel the inclusion of some species not here enumerated, such as species of Lycopodium.

The question of nomenclature is a troublesome one because American botanists are not united upon rules for the names of plants. As many of the students in forestry plan to enter the United States Forest Service, the rules for botanical nomenclature adopted by the Forest Service have generally been followed in the names of both trees and shrubs, the oldest clear specific or varietal name being used, dating from the foundation of binomial nomenclature by Linnaeus in his "Species Plantarum," published in 1753. The more commonly used synonyms are given and, as a matter of historical interest, the original combinations of genera and species and the dates of publication are added.

Following the rules adopted by Sudworth in his "Check List of the Forest Trees of the United States" (Bulletin, No. 17, Division of Forestry, 1898), and by zoölogists generally, all specific and varietal names are written with a small initial letter both in names adopted here and also in quotation of synonyms used by other authors. See Sudworth's "Nomenclature of the Arborescent Flora of the United States" (Bulletin, No. 14, Division of Forestry, 1897), pp. 341 355, for laws and codes of nomenclature adopted by the Forest Service as a standard for scientific names of plants.

SPERMATOPHYTA. Seed Plants.

GYMNOSPERMAE.

Taxaceae. Yew Family.

Taxus Linnaeus. Yew.

Taxus canadensis Marshall. Ground Hemlock, American Yew.
Shady woods, frequent.

Pinaceae. Pine Family.

Pinus Linnaeus. Pine.

Pinus strobus Linnaeus. White Pine, Weymouth Pine.
Most important commercial species in the Harvard Forest. Found abundant in almost all situations except deep swamps.

Pinus rigida Miller. Pitch Pine.
Occurs in a few small colonies in dry situations. Of little economic importance in this region.

Pinus resinosa Aiton. Red Pine, Norway Pine.
Rare in Harvard Forest, a small colony in Prospect Hill tract and individuals in other parts. Other small groups in the vicinity of Petersham.

Larix Miller. Larch.

Larix laricina (Du Roi) Koch. American Larch, Black Larch, Tamarack. Hackmatack.
Pinus laricina Du Roi. [1771.]
Larix americana Michaux. [1803.]
Found in groups or scattered individuals on swamps or bogs, usually small.

Larix larix (L.) Karsten. European Larch.
Pinus larix Linnaeus. [1753.]
Larix decidua Miller. [1768.]
Larix europaea De Candolle. [1805.]
Planted in Petersham, rarely escaped.

Picea Link. Spruce.

Picea rubens Sargent. Red Spruce.
Picea nigra rubra Engelmann.
Picea rubra (Poir.) Dieterich.
Abies rubra Poiret.

Probably once abundant in Northeast tract, now nearly all cut off. Slopes of Prospect Hill and adjacent swamps also in Meadow Water tract.

There is much disagreement as to the proper specific name to be applied to this tree. The name used by Sudworth in his "Check List" and by Professor C. S. Sargent in his "Manual of the Trees of North America" is here retained though some authorities prefer the older *Picea rubra*.

Picea mariana (Mill.) B.S.P. Black Spruce, Swamp Spruce.
Abies mariana Miller.

Common on bogs in surrounding country but rare in Harvard Forest. In swamp on Meadow Water tract where it cannot be described as exactly typical but appears as if in transition from Red to Black Spruce as the former extends from dry slopes into the swamp.

Picea abies (L.) Karsten. Norway Spruce.
Pinus abies Linnaeus [1753.]
Picea excelsa (Lam.) Link.
Pinus excelsa Lamarck. [1778.]

Planted in Petersham and rarely naturalized.

Abies Hill. Fir.

Abies balsamea (L.) Miller. Balsam Fir, Balm of Gilead Fir.

Planted in Petersham, probably native although not yet found in Harvard Forest. Is native in adjoining towns.

Tsuga (Endl.) Carr. Hemlock.

Tsuga canadensis (L.) Carrière. Hemlock.

Common on cool north situations and occasionally as an understory to White Pine.

Thuya Linnaeus. Arbor Vitae.

Thuya occidentalis Linnaeus. Arbor Vitae, White Cedar.

Planted in Petersham.

Juniperus Linnaeus. Juniper.

Juniperus virginiana Linnaeus. Red Cedar, Savin.

Rather rare. In pastures.

Juniperus nana Willdenow. [1806.]
Juniperus communis of many writers. Common Juniper. Prostrate Juniper.

In abandoned pastures.

ANGIOSPERMAE.

DICOTYLEDONEAE.

Salicaceae. Willow Family.

Salix Linnaeus. Willow, Osier.

Salix lucida Muhlenberg. Shining Willow, Glossy Willow.
Rather rare in Harvard Forest.

Salix fragilis Linnaeus. Crash Willow, Brittle Willow.
Native of Europe. Planted in Petersham

Salix alba Linnaeus. White Willow.
Native of Europe. Planted in Petersham

Salix cordata Muhlenberg. Heart-leaved Willow.
Common. Wet ground.

Salix discolor Muhlenberg. Glaucous Willow, Pussy Willow.
Very common. Roadsides and low places

Salix humilis Marshall. Prairie Willow.
Dry ground. Not uncommon.

Salix sericea Marshall. Silky Willow.
Common. Usually near streams or in wet situations.

Salix petiolaris J. E. Smith. Slender Willow.
Occasional. On wet ground.

Salix bebbiana Sargent. Beaked Willow.
Salix rostrata Richardson.
Common. Moist and dry situations.

Populus Linnaeus. Poplar, Aspen.

Populus alba Linnaeus. White or Silver-leaved Poplar, Abele, White Park.
Introduced in Petersham. A European species.

Populus tremuloides Michaux American or Quaking Aspen, Poplar, Popple, Quiver-leaf.
Very common. Clearings and dry ground.

Populus grandidenta Michaux. Large-toothed Aspen, Poplar, Popple.
Common. Clearings, roadsides, dry and wet ground

Populus candicans Aiton. [1789.] Balm of Gilead.
Populus balsamifera candicans (Ait.) Gray.
Introduced in Petersham and found reproducing itself by root sprouts near old house sites, etc.

Myricaceae. Sweet Gale Family.

Myrica Linnaeus.

Myrica gale Linnaeus. Sweet Gale.
In swamps and borders of ponds and streams.

Myrica carolinensis Miller. Bayberry, Candlewood, Waxberry.
In pastures and abandoned fields.
This species is found in most Manuals and Floras of eastern North America under the name of *Myrica cerifera* which is now restricted to a more southern type.

Comptonia Banks.

Comptonia peregrina (L.) Coulter. Sweet Fern.
Liquidambar peregrina Linnaeus. [1753.]
Myrica asplenifolia Linnaeus. [1753.]
Comptonia asplenifolia (L.) Gaertner.
Common, chiefly in pastures and abandoned fields, a weed.

Juglandaceae. Walnut Family.

Juglans Linnaeus. Walnut.

Juglans cinerea Linnaeus. Butternut, White Walnut, Oil Nut.
Frequent, woods and roadsides.
Juglans nigra Linnaeus. Black Walnut.
Rare, planted in Petersham.

Hicoria. Hickory.

Hicoria ovata (Mill.) Britton. Shagbark or Shellbark Hickory.
Juglans ovata Miller [1768.]
Carya ovata (Mill.) K. Koch.
Carya alba Nutt. [1818.]
Not common in Harvard Forest but found more or less abundantly in neighboring woods and fields.
Hicoria glabra (Mill.) Britton. Pignut, Broom Hickory.
Juglans glabra Miller. [1768.]
Carya glabra (Mill.) Spach.
Carya porcina Nuttall. [1818.]
Not very common, sometimes found associated with Shagbark Hickory.
Hicoria microcarpa (Nutt.) Britton. Small-fruited Hickory.
Carya microcarpa Nuttall.
A single tree of what appears to be this species occurs on the Waldo farm in Petersham. Its classification is difficult, as is the case with many of the hickory trees found in New England, especially those in the Pignut group.

Betulaceae. Birch Family.

Corylus Linnaeus. Hazelnut, Filbert.

Corylus americana Walter. Common Hazelnut.
Rare in Harvard Forest.
Corylus rostrata Aiton. Beaked Hazelnut, Filbert.
Common, roadsides, woods, and thickets.

Ostrya Scopoli. Hop Hornbeam, Ironwood.

Ostrya virginiana (Mill.) K. Koch.
Carpinus virginiana Miller. [1768.]
Ostrya virginica Willdenow. [1805.] American Hop Hornbeam, Leverwood, Ironwood, Deerwood.
Frequent in the Harvard Forest.

Carpinus Linnaeus. Hornbeam, Ironwood.

Carpinus caroliniana Walter. [1788.]

Carpinus americana Michaux. [1803.] American Hornbeam, Blue or Water Beech.

Local, not common as the Hop Hornbeam.

Betula Linnaeus. Birch.

Betula populifolia Marshall. Gray Birch, Old Field Birch.

Very common. A forest weed, on pastures, clearings, and in woods.

Betula papyrifera Marshall. [1785.] White, Canoe, or Paper Birch.

Betula alba papyrifera (Marsh.) Spach.

Betula papyracea Aiton. [1789.]

Frequent, most abundant in Meadow Water tract.

Betula lenta Linnaeus. Black, Cherry, or Sweet Birch.

Common on well-drained soils.

Betula lutea Michaux fils. Yellow Birch, Silver Birch.

Frequent on rich moist or wet situations.

Alnus Hill. Alder.

Alnus incanus (L.) Moench. Speckled or Hoary Alder.

Common on wet ground, swamps and borders of streams.

Form here is not so typically gray tomentose beneath as occurs further north and in some other regions.

Alnus rugosa (Du Roi) Sprenger. Smooth Alder.

Betula alnus rugosa Du Roi [1771.]

Alnus serrulata Willdenow. [1805.]

Less common than *A. incana*.

Plants with characters intermediate between these two alders are common in Petersham.

Fagaceae. Beech Family.

Fagus Linnaeus. Beech.

Fagus grandifolia Ehrhart. [1788.] Beech, American Beech.

Fagus ferruginea Aiton. [1789.]

Fagus americana Sweet. [1826.]

Occasional as individuals or groups in well-drained woods.

Castanea Hill. Chestnut.

Castanea dentata (Marsh.) Borkhausen. [1800.] American Chestnut.

Fagus castanea dentata Marshall. [1785.]

Castanea sativa americana Sargent.

Castanea vesca americana Michaux. [1803.]

Common and important tree.

Quercus Linnaeus. Oak.

Quercus alba Linnaeus. White Oak.

Common, in various soils and situations.

Quercus prinus Linnaeus. Chestnut Oak.

Found near Petersham (Shutesbury) but not yet noted in Harvard Forest.

Quercus rubra Linnaeus. Red Oak.
Common, especially in rich soil and protected situations.
Of commercial importance in Harvard Forest.

Quercus coccinea Muenchhausen. Scarlet Oak.
Rather rarely found in Harvard Forest.

Quercus velutina Lamarck. [1783.] Yellow Oak, Black Oak.
Quercus tinctoria Bartram. [1791.]
Quercus coccinea tinctoria (Bartr.) A. De Candolle.
Common throughout the drier or better drained parts of the forest.

Ulmaceae. Elm Family.

Ulmus Linnaeus. Elm.

Ulmus americana Linnaeus. American Elm, White Elm.
Common, woods and fields.

Ulmus fulva Michaux. Slippery Elm, Red Elm.
Ulmus pubescens Walter [1788] has been taken by some authors for this species but is generally ignored because Walter's description is inadequate and leaves uncertainty as to the tree he attempted to name.
Rather rare, planted in Petersham and apparently native in vicinity of the Harvard Forest.

Ulmus campestris Linnaeus. English Elm.
This native of Europe is planted in Petersham and is rarely found escaped from cultivation. Other foreign species of elms or hybrids are also planted.

Berberidaceae. Barberry Family.

Berberis Linnaeus. Barberry.

Berberis vulgaris Linnaeus. Common Barberry.
Native of Europe. Planted in Petersham and occasionally naturalized in Harvard Forest.

Lauraceae. Laurel Family.

Sassafras Nees.

Sassafras sassafras (L.) Karsten. Sassafras.
Laurus sassafras Linnaeus. [1753.]
Sassafras variifolium (Salisb.) Kuntze.
Laurus variifolia Salisbury. [1796.]
Sassafras officinale Nees and Ebermeir. [1830.]
Rather rare, on dry ground, usually small.

Benzoin Fabricius.

Benzoin aestivale (L.) Nees. Spine Bush, Fever Bush.
Laurus aestivalis Linnaeus. [1753.]
Lindera benzoin (L.) Blume.
Laurus benzoin Linnaeus. [1753.]
Benzoin benzoin (L.) Coulter.
Frequent, in moist or wet places.

Saxifragaceae. Saxifrage Family.

Ribes Linnaeus. Currant, Gooseberry.

Ribes cynosbati Linnaeus. Prickly Gooseberry.

Occasionally found in woods and along fences.

Ribes vulgare Lamarck. Red Currant.

Native of Europe, cultivated in gardens and occasionally found escaped in woods. Has been called *Ribes rubrum*, which name, however, properly belongs to another species.

Philadelphus Linnaeus. Mock Orange, Syringa.

Philadelphus coronarius Linnaeus. Mock Orange.

Old World species, planted and occasionally escaped from cultivation.

Hamamelidaceae. Witch Hazel Family.

Hamamelis Linnaeus. Witch Hazel.

Hamamelis virginiana Linnaeus. Witch Hazel.

A common shrub, found in both moist and moderately dry situations, chiefly in shady woods.

Platanaceae. Plane Tree Family.

Platanus Lindley. Buttonwood, Sycamore.

Platanus occidentalis Linnaeus.

Very rare in Harvard Forest, rich soil.

Rosaceae. Rose Family.

Spiraea Linnaeus.

Spiraea latifolia (Ait.) Borkhausen. Meadow-sweet.

Formerly called *Spiraea salicifolia* by many writers on the flora of Northeastern America, but that is a distinct species not known to occur within this range.

Common, pastures, open woods, moist ground, roadsides.

Spiraea tomentosa Linnaeus. Hardhack.

Common, pastures, low grounds.

Various introduced Spiraeas are planted in Petersham or rarely found near home sites in the Harvard Forest. The hybrid *Spiraea vanhouttei* is one of these.

Malus Hill. Apple.

Malus malus (L.) Britton. Common Apple.

Pyrus malus Linnaeus. [1753.]

Malus sylvestris Miller. [1768.]

This native of the Old World is very generally escaped from cultivation and has become naturalized along roadsides, in fields, and in woods, showing great variation in fruit and other characters. *Malus soulardi* (Bailey) Britton. Soulard Crab. *Pyrus soulardi* Bailey. An interesting apparent hybrid between the Common Apple of the Old World and *Malus ioensis*, a crab apple native in the Middle States. It was planted on the Prospect Hill tract, with other apples, by former owners.

Pyrus Linnaeus. Pear Family.

Pyrus communis Linnaeus. Common Pear.

This native of the Old World has been planted and rarely escaped from cultivation.

Cydonia Miller. Quince.

Cydonia cydonia (L.) Persoon. Common Quince.

Pyrus cydonia Linnaeus. [1753.]

Cydonia vulgaris Persoon. [1807.]

Introduced and persisting in abandoned orchards, Prospect Hill tract.

Aronia Persoon. Chokeberry, Dogberry.

Aronia atropurpurea Britton. Purple-fruited Chokeberry.

Pyrus arbutifolia atropurpurea (Britton) Robinson.

Frequent.

Aronia nigra (Med.) Dippel. Black Chokeberry.

Hahnia arbutifolia nigra Medicus. [1793.]

Pyrus nigra (Med.) Sargent.

Sorbus melanocarpa (Willd.) Heynhold.

Pyrus melanocarpa (Mich.) Willdenow.

Mespilus arbutifolia melanocarpa Michaux. [1803.]

Very common. The chokeberries in this region show a great deal of variation, so that other species or varieties may yet be separated.

Sorbus americana Marshall. [1785.] American Mountain Ash.

Pyrus americana (Marsh.) De Candolle.

Rather rare, in woods and along roadsides, sometimes planted for ornament.

Amelanchier Medicus. Juneberry, Serviceberry, Shadbush.

Amelanchier canadensis (L.) Medicus. Juneberry, Serviceberry.

Mespilus canadensis Linnaeus. [1753.]

Common, usually in dry or well-drained woods, usually small or shrub-like, rarely becoming large with a trunk approaching a foot in diameter and attaining 50 feet or more in height.

Amelanchier oblongifolia (T. & G.) Roemer. Swamp Shadbush.

Amelanchier canadensis oblongifolia Torrey & Gray. [1840.]

Frequent, usually on moist or wet ground.

Amelanchier spicata (Lam.) C. Koch.

Uncommon, Prospect Hill tract and other places.

There is much variation among the Juneberries of this region and it is possible one or two additional species may be segregated.

Crataegus Linnaeus. Hawthorn, White.

Crataegus rotundifolia Moench. [1785.]

Crataegus coccinea rotundifolia (Moench.) Sargent.

Occasional.

Crataegus pastorum Sargent. Pasture Thorn.

Frequent, neglected pastures, open woods, along fences and roads.

Crataegus monogyna Jacquin. English Hawthorn, White Thorn.

Rarely escaped from cultivation. By American writers often called

C. oxyacantha, a name properly belonging to another species.

It is probable that more so-called species of Crataegus may be found in the Harvard Forest and vicinity. There is much confusion among authors in regard to the specific limits and nomenclature.

Rubus Linnaeus. Raspberry, Blackberry, Bramble.

Rubus odoratus Linnaeus. Purple Flowering Raspberry.
Not common, occurs on the different tracts of the Harvard Forest.

Rubus strigosus Michaux. Wild Raspberry.
Common.

Rubus occidentalis Linnaeus. Thimbleberry, Black Cap Raspberry.
Frequent.

Rubus triflorus Richards.
Common. Wet woods.

Rubus allegheniensis Porter. High Blackberry.
Common.

Rubus recurvans Blanchard.
Occasional. Roadsides.

Rubus canadensis Linnaeus.
Barre Road, banks of Swift River.

Rubus setosus Bigelow.
Near Brooks's Pond.

Rubus hispidus Linnaeus.
Common. Low woods.

Rubus villosus Aiton. Dewberry.
Common. Open places.

Rosa Linnaeus. Rose.

Rosa nitida Willdenow.
In Meadow Water swamp.

Rosa rubiginosa Linnaeus. Sweetbrier.
Occasional, escaped from cultivation into old pastures.

Rosa cinnamomea Linnaeus. Cinnamon Rose.
This Old World rose, with semidouble flowers, occurs on the Meadow Water tract and other parts near sites of former homesteads.

Prunus Linnaeus. Plum, Cherry, Peach.

Prunus serotina Ehrhart. Wild Black Cherry, Rum Cherry.
Common, in woods, along roadsides, and in pastures.
Becomes of good timber size in moist situations in mixture with white ash, yellow birch, red maple, etc.

Prunus virginiana Linnaeus. Choke Cherry.
Frequent in open woods and along roadsides.

Prunus pennsylvanica Linnaeus fils. Wild Red Cherry, Bird, Pin, or Fire Cherry.
Very common on old pastures, on old burned areas, along roadsides, and in open woods with quaking aspen, etc.

Prunus avium Linnaeus. Sweet, Black, or Mazzard Cherry.
Introduced from Europe, the common Garden Cherry of New England, occasionally found escaped in woods.

Prunus cerasus Linnaeus. Sour or Morello Cherry.

From Europe, cultivated and occasionally becoming wild along fences, roadsides, etc.

Prunus nigra Aiton. Canada Plum, Horse Plum.

Occasional along roadsides and fences. Probably escaped from cultivation and not strictly native in this locality.

Prunus persica (L.) Stokes. Peach.

Amygdalus persica Linnaeus.

In abandoned orchards and escaped from cultivation.

Leguminosae. Pulse Family.

Robinia Linnaeus. Locust.

Robinia pseudacacia Linnaeus. Locust, Common, Black, Yellow, and White Locust, False Acacia.

Escaped from cultivation and naturalized in Harvard Forest and other parts of Petersham.

Anacardiaceae. Cashew Family.

Rhus Linnaeus. Sumachs.

Rhus hirta (L.) Sudworth. Staghorn Sumach.

Datisca hirta Linnaeus. [1753.]

Rhus typhina Linnaeus. [1760.]

Common in old fields, clearings, and along roads and fences.

Rhus glabra Linnaeus. Smooth Sumach.

Often occurs with Staghorn Sumach and about equally common.

An apparent hybrid between *R. typhina* and *R. glabra* occurs on the Prospect Hill tract. It is a pistillate plant.

Rhus copallina Linnaeus. Mountain Sumach, Dwarf Sumach.

Not common, in old pastures and open woods.

Rhus vernix Linnaeus. [1753.] Poison Sumach, Poison Dogwood, Poison Elder.

Rhus venenata De Candolle. [1825.]

Frequent on wet ground or swamps.

Rhus toxicodendron Linnaeus. Poison Ivy, Poison Oak.

Very common, usually trailing or climbing, sometimes bushy or shrub-like.

Aquifoliaceae. Holly Family.

Ilex Linnaeus. Holly.

Ilex verticillata (L.) A. Gray. Winterberry, Black Alder.

Prinos verticillata Linnaeus.

Very common, usually in moist or wet ground; very variable.

Ilex laevigata (Pursh.) A. Gray. Smooth Winterberry.

Prinos laevigata Pursh.

Local but common in some swamps, Prospect Hill tract, also Meadow Water.

Ilicioides Dumont.

Ilicioides mucronata (L.) Britton. Mountain Holly.

Vaccinium mucronatum Linnaeus. [1753.]

Nemopanthus mucronata (L.) Trelease.
Nemopanthus canadensis De Candolle. [1821.]
Common in swamps or wet ground in woods.

While the generic name Nemopanthus of Rafinesque [1819] has been used most often it seems proper that the older Ilicioides [1802] should be followed.

Celastraceae. Staff Tree Family.

Celastrus Linnaeus.

Celastrus scandens Linnaeus. Waxwork, Climbing Bitter-sweet.
Occasional, Prospect Hill tract and other places.

Euonymus Linnaeus. Spindle Tree.

Euonymus atropurpureus Jacquin. Burning Bush. Wahoo.
Planted and naturalized at Harvard House, Prospect Hill tract.

Aceraceae. Maple Family.

Acer Linnaeus. Maple.

Acer pennsylvanicum Linnaeus. Striped Maple, Moosewood.
Occurs scattered through woods, frequent.

Acer spicatum Lamarck. Spiked Maple, Mountain Maple.
Much less abundant than the Striped Maple.

Acer saccharum Marshall. [1785.] Sugar Maple, Rock Maple.
Acer saccharinum Wangenheim [1787], not Linnaeus [1753].
Common, attaining good size and of commercial importance.

Acer rubrum Linnaeus. Red, Swamp, or Soft Maple.
Very common, especially in low ground. Valued as cord-wood.

Acer saccharinum Linnaeus [1753], not Wangenheim [1787]. White or Silver Maple also Soft Maple.
Acer dasycarpum Ehrhart. [1789.]
Planted but not indigenous in this locality.

Acer negundo Linnaeus. [1753.] Ash-leaved Maple, Box Elder.
Negundo aceroides Moench. [1794.]
Planted occasionally but not native in this region.

Acer platanoides Linnaeus. Norway Maple.
Native of Europe, planted in Petersham as a street or shade tree.
Other species of Maples are rarely planted in the town.

Hippocastanaceae. Horsechestnut Family.

Aesculus Linnaeus. Horsechestnut, Buckeye.

Aesculus hippocastanum Linnaeus. Horsechestnut.
Native of Europe, planted for ornament and occasionally escaped in woods.

Rhamnaceae. Buckthorn Family.

Rhamnus Linnaeus. Buckthorn.

Rhamnus cathartica Linnaeus. Common Buckthorn.
Native of Europe, planted and frequently become naturalized.

Vitaceae. Grape Family.

Vitis Linnaeus. Grape.

Vitis labrusca Linnaeus. Common Wild Grape, Northern Fox Grape.
Common.

Vitis aestivalis Michaux. Summer Grape.
On stone walls, apparently native.

Vitis vulpina Linnaeus. [1753.] River-bank Grape.
Vitis riparia Michaux. [1803.]
Occasionally on stone walls or fences, seeming native.

Grapes of various varieties were formerly planted along stone walls and fences by members of the Adonai Showo community and perhaps others. These plants now have the appearance of being at least half wild. They are north on the Prospect Hill tract.

Psedera Necker (Ampelopsis). Virginia Creeper, American Woodbine.

Psedera quinquefolia (L.) Greene.
Hedera quinquefolia Linnaeus. [1753.]
Ampelopsis quinquefolia (L.) Michaux. [1803.]
Parthenocissus quinquefolia (L.) Planchon. [1887.]
Common.

Psedera vitaceae Greene.
Roadsides, apparently native, perhaps escaped from cultivation.

Tiliaceae. Linden Family.

Tilia Linnaeus. Linden, Basswood.

Tilia americana Linnaeus. Basswood, American Linden, Whitewood.
Occurs in mixture with other deciduous trees of Harvard Forest in rich situations.

Phymelaeceae. Mezereum Family.

Dirca Linnaeus. Leatherwood.

Dirca palustris Linnaeus. Wicopy, Leatherwood, Moosewood.
Rare. Found along roadside, Slab City tract.

Araliaceae. Ginseng Family

Aralia Linnaeus.

Aralia hispida Ventenat. Bristly Sarsaparilla.
Occasional.

Cornaceae. Dogwood Family.

Cornus Linnaeus. Cornel, Dogwood.

Cornus florida Linnaeus. Flowering Dogwood, Boxwood.
Local in Petersham, not yet found wild in Harvard Forest.

Cornus rugosa Lamarck. [1786.] Round-leaved Cornel.
Cornus circinata L'Heritier. [1788.]
Occasional, roadsides and open woods.

Cornus amomum Miller. [1768.] Silky Cornel.
Cornus sericea Linnaeus. [1771.]
Rather rare in Harvard Forest, on moist ground.

Cornus obliqua Rafinesque. [1819.] Narrow-leaved Silky Cornel.

Cornus purpusi Koehne. [1899.]

Rare in Harvard Forest, moist ground and liable to be confused with *C. amomum*.

Cornus stolonifera Michaux. Red-osier Dogwood.

Planted in Petersham but not yet recognized as wild there.

Cornus racemosa Lamarck. [1786.] Panicled Cornel.

Cornus paniculata L'Heritier. [1788.]

Cornus candidissima (?) Marshall. [1785.]

Frequent, along roadsides and in woods.

Cornus alternifolia Linnaeus fils. Alternate-leaved Dogwood.

Common along roadsides and in open woods.

Nyssa Linnaeus. Tupelo, Pepperidge, Sour Gum.

Nyssa sylvatica Marshall. [1785.]

Nyssa multiflora Wangenheim. [1787.]

Frequent, chiefly in moist or wet ground.

Ericaceae. Heath Family.

Rhododendron Linnaeus.

Rhododendron viscosum (L.) Torrey. Clammy Azalea, White Swamp Azalea, or Honeysuckle.

Azalea viscosa Linnaeus.

Uncommon in swampy situations.

Rhododendron canescens (Mich.) Porter. Purple, Pink, or Wild Azalea or "Honeysuckle."

Azalea canescens Michaux.

Common in swamps, also in drier ground.

This is the *Azalea nudiflora* or *Rhododendron nudiflorum* of various Manuals and Floras of eastern North America.

The true *R. nudiflorum* however, which closely resembles *R. canescens,* is not known to occur in this locality.

Rhododendron canadense (L.) B.S.P. Rhodora.

Rhodora canadensis Linnaeus. [1762.]

Rhododendron rhodora D. Don. [1834.]

Common in a few localities in Harvard Forest and other parts of Petersham.

Kalmia Linnaeus.

Kalmia latifolia Linnaeus. Mountain Laurel, Calico Bush.

Plentiful in a few localities and frequent scattered individuals. In woods and thickets especially under shade of overwood.

Kalmia angustifolia Linnaeus. Sheep Laurel, Lambkill.

Old fields and wet ground, common.

Kalmia polifolia Wangenheim. [1787.] Pale or Swamp Laurel.

Kalmia glauca Aiton. [1811.]

Occasional, in cold sphagnum swamps.

Leucothoe D. Don. Fetter Bush.

Leucothoe racemosa (L.) Gray.

Andromeda racemosa Linnaeus. [1753.]

Uncommon or rare, wet places.

Andromeda Linnaeus.

Andromeda glaucophylla Link. Bog or Marsh Rosemary.

Rare or local in cold wet bogs or "muskegs," not yet noticed in Harvard Forest. This is enumerated as *Andromeda polifolia* Linnaeus in many Manuals and Floras of North America but that name applies to the European species which is now generally regarded as distinct.

Lyonia Nuttall.

Lyonia ligustrina (L.) De Candolle.
Vaccinium ligustrinum Linnaeus. [1753.]
Andromeda ligustrina (L.) Muhlenberg.
Xolisma ligustrina (L.) Britton.

Common throughout the region, preferring moist or wet places.

Chamaedaphne Moench.

Chamaedaphne calyculata (L.) Moench. Leather Leaf, Cassandra.
Andromeda calyculata Linnaeus. [1753.]
Cassandra calyculata (L.) D. Don.

Wet sphagnum swamps. Very abundant on Meadow Water tract covering many acres of the shallower parts of the pond.

Epigaea Linnaeus. Mayflower, Trailing Arbutus.

Epigaea repens Linnaeus. Mayflower.

Plentiful in localities.

Gaultheria Linnaeus.

Gaultheria procumbens Linnaeus. Checkerberry, Teaberry.

Abundant in localities, woods and clearings.

Chiogenes Salisbury.

Chiogenes hispidula (L.) Torrey & Gray. Creeping Snowberry.
Vaccinium hispidulum Linnaeus

Occurs on sphagnum in cold wet bogs.

Vaccinium Linnaeus. Blueberry, Cranberry.

Vaccinium pennsylvanicum Lamarck. Dwarf or Early Blueberry.

Common, dry situations, fields and woods.

Vaccinium vacillans Kaln. Late Low Blueberry.

Common, dry soil.

Vaccinium canadense Kalm. Canade Blueberry.

Apparently uncommon, wet places.

Vaccinium corymbosum Linnaeus. High-bush or Tall Blueberry.

Common, swamps or drier situations.

Vaccinium atrococcum (Gray) Heller. Black High Blueberry.
Vaccinium corymbosum atrococcum Gray.

Occasional. It seems doubtful whether this blueberry should be considered specifically distinct from V. corymbosum.

Vaccinium oxycoccus Linnaeus. Small-fruited Cranberry.

Uncommon. Meadow Water tract.

Vaccinium macrocarpon Aiton. Large-fruited Cranberry
Oxycoccus macrocarpus (Ait.) Pursh.
Plentiful on some sphagnum-covered bogs and wet places.

Gaylussacia Humboldt Bonpland & Knuth. Huckleberry

Gaylussacia baccata (Wang.) K. Koch. Black Huckleberry.
Andromeda baccata Wangenheim. [1787.]
Vaccinium resinosum Aiton. [1789.]
Gaylussacia resinosa (Ait.) Torrey & Gray.
Common, both wet and dry situations, old pastures, etc.

Oleaceae. Olive Family.

Fraxinus Linnaeus. Ash.

Fraxinus americana Linnaeus. White Ash.
Common, in rich soils. Of commercial importance in Harvard Forest.
Fraxinus nigra Marshall. [1785.] Black Ash.
Fraxinus sambucifolia Lamarck. [1786.]
Occurs in swamps, not plentiful and of little economic importance here.

Syringa Linnaeus. Lilac.

Syringa vulgaris Linnaeus. Common Lilac.
Escaped from cultivation, abandoned homesteads, etc.

Ligustrum Linnaeus. Privet.

Ligustrum vulgare Linnaeus. Common Privet.
Rarely naturalized from cultivated plants.

Solanaceae. Nightshade Family.

Solanum dulcamara Linnaeus. Bittersweet.
Occasional. Naturalized from Europe.

Bignoniaceae. Trumpet Creeper Family.

Tecoma Jussieu.

Tecoma radicans (L.) De Candolle. Trumpet Creeper.
Bignonia radicans Linnaeus. [1753.]
Escaped from cultivation, old house site on Prospect Hill tract.

Rubiaceae. Madder Family.

Cephalanthus Linnaeus.

Cephalanthus occidentalis Linnaeus. Button-bush.
Very wet boggy places, Meadow Water tract, etc.

Caprifoliaceae. Honeysuckle Family.

Diervilla Moench.

Diervilla diervilla (L.) MacMillan. Bush Honeysuckle.
Lonicera diervilla Linnaeus. [1753.]
Diervilla lonicera Miller. [1759.]
Diervilla trifida Moench. [1794.]
Common, dry woods, roadsides, and old fields.

Lonicera Linnaeus. Honeysuckle.

Lonicera coerulea Linnaeus. Blue-fruited Honeysuckle.
Common on wet meadows or swamps.
This species of Honeysuckle is found in some of its forms in the northern parts of Europe and Asia as well as North America. Our form is sometimes differentiated as *Lonicera coerulea villosa*.

Lonicera canadensis Marshall. [1785.] Canadian Honeysuckle.
Lonicera ciliata Muhlenberg. [1813.]
In woods, occasional.

Lonicera dioica Linnaeus. [1753.] Glaucous Honeysuckle.
Lonicera glauca Hill. [1769.]
In woods, rare.

Lonicera tartarica Linnaeus. Tartarian Honeysuckle.
Is rarely found escaped from cultivation.

Symphoricarpos Jussieu.

Symphoricarpos racemosus laevigatus Fernald. Snowberry.
Escaped from cultivation, rare.

Viburnum Linnaeus.

Viburnum alnifolium Marshall. [1785.] Hobble-bush. Witch Hobble.
Viburnum lantanoides Michaux. [1803.]
Numerous colonies and individuals, mainly in rich shady woods.

Viburnum acerifolium Linnaeus. Maple-leaved Viburnum or Arrow-wood.
Common, dry woods, openings, and roadsides.

Viburnum dentatum Linnaeus. Arrow-wood.
Common, open woods, roadsides.

Viburnum cassinoides Linnaeus. Withe-rod.
Very common. Chiefly rich moist soils and swamps.

Sambucus Linnaeus. Elder.

Sambucus canadensis Linnaeus. Common or Black-Berried Elder.
Common in moist places.

Sambucus pubens Michaux. Red-berried Elder.
Sambucus racemosa is the name sometimes given to our Red-berried Elder by American authors but it is here restricted to the European plant which was named by Linnaeus and which closely resembles ours.

NOTES ON THE GROWTH OF WESTERN YELLOW PINE IN THE BLACK HILLS

Gordon Parker

The only tree of commercial importance in the Black Hills of South Dakota is the Western Yellow Pine (*Pinus ponderosa scopulorum*, Engelm.). There are a few other trees in that section which sometimes attain timber size, notably white spruce (*Picea canadensis*, [Mill.] B.S.P.), quaking aspen (*Populus tremuloides*, Michx.), and in one very small area a little lodgepole pine (*Pinus murrayana*, "Oreg. Com."), but they are all either so poor in quality or so small in quantity that they practically never appear in the local markets.

Last summer a study was undertaken in the Black Hills National Forest to determine a definite relation between the age of this western yellow pine and its diameter at breast height for that region. The writer assisted in collecting and working up the data on this study. A brief account of the work and of its results may be of interest.

The data was collected on ten different sections in five townships, thus largely obviating the effect of any one set of factors of locality since average figures were desired. Several logging operations in different places afforded an excellent opportunity for the work on trees of timber size (twelve inches D B H and up), and sufficient trees of smaller sizes were cut to give at least twelve trees in each inch class of D B H down to six inches.

There was little or no variation of stump height according to the size of the tree. The stumps were usually cut about as low as the nature of the ground would permit, the average height of stump of 366 trees being 1.28 feet, or 15.36 inches.

An analysis of seedlings up to eighteen inches high was made on a total of 313 trees, the measurement being total height growth for age. The results gave the following table: —

Height inches	Age years	Height inches	Age years	Height inches	Age years
1	1.2	7	7.8	13	12.6
2	2.2	8	8.9	14	13.3
3	3.3	9	9.7	15	13.9
4	4.5	10	10.5	16	14.5
5	5.7	11	11.3	17	15.4
6	6.7	12	12.0	18	16.2

And from this table it is seen that the average age of a stump 15.36 inches high is just over fourteen years.

Stump analyses were made in the regulation way on 367 trees, the annual rings being counted from the outside in along the average radius, every tenth ring being marked, and the measurements then being taken from the center out to each marked ring, accurate to the nearest fortieth of an inch. DBH measurements also were carefully taken on each tree. Although notes were made as to situation, slope, tree class, etc., those facts were not considered in working up the data. It was thought that by combining all the trees in a single set of figures the results would be fairly typical of the stands on any large areas in this region, since such stands always contain a more or less constant proportion of faster and slower growing trees.

The average age at the stump, taken from 366 trees, was 169 years. Adding the seedling age to this figure gives 183 years as the average total age of the trees analyzed. The youngest tree was 65 years old at the stump, and the oldest 368 years.

Great variation in the rate of growth of individual trees was found. The extremes noted were 170 years of age with a stump diameter inside bark of 6.2 inches, and 194 years of age with a stump diameter of 33.8 inches. The average tree of average age, 183 years, should have a stump diameter of 15.3 inches.

The DBH measurements were plotted on DIB at stump and the relation between them was thus established. This gave the following table based on 351 trees.

D I B at stump inches	D B H inches	D I B at stump inches	D B H inches	D I B at stump inches	D B H inches
6	6.0	14	14.1	22	21.2
7	6.9	15	15.0	23	22.1
8	7.8	16	15.9	24	22.9
9	8.8	17	16.8	25	23.7
10	9.9	18	17.7	26	24.5
11	11.0	19	18.6	27	25.3
12	12.1	20	19.5	28	26.2
13	13.2	21	20.4		

Then the radial measurements were plotted on age, the results carefully averaged, and the slight irregularities removed by a curve. Through this set of figures the following table was obtained:—

Actual age years	Age at stump years	Radius inside bark on stump inches	D I B at stump inches	D B H inches
10	.	. .	. .	.
20	6	.3	.6	.
30	16	.9	1.8	
40	26	1.5	3.0	
50	36	2.15	4.3	
60	46	2.8	5.6	
70	56	3.45	6.9	6.8
80	66	4.0	8.0	7.8
90	76	4.5	9.0	8.8
100	86	4.95	9.9	9.8
110	96	5.4	10.8	10.8
120	106	5.8	11.6	11.7
130	116	6.15	12.3	12.4
140	126	6.5	13.0	13.2
150	136	6.8	13.6	13.8
160	146	7.1	14.2	14.3
170	156	7.35	14.7	14.8
180	166	7.6	15.2	15.2
190	176	7.8	15.6	15.6
200	186	8.0	16.0	15.9
210	196	8.2	16.4	16.3
220	206	8.4	16.8	16.7
230	216	8.6	17.2	17.0
240	226	8.8	17.6	17.4
250	236	9.0	18.0	17.7
260	246	9.2	18.4	18.1
270	256	9.4	18.8	18.4
280	266	9.6	19.2	18.8
290	276	9.8	19.6	19.1
300	286	9.95	19.9	19.4
310	296	10.15	20.3	19.8

Finally plotting these DBH figures on age and smoothing out the curve the final table was secured.

Age years	DBH inches	Age years	DBH inches	Age years	DBH inches
60	5.8	130	12.4	228	17.0
62	6.0	138	13.0	230	17.1
70	6.8	140	13.2	240	17.4
72	7.0	150	13.8	250	17.7
80	7.8	154	14.0	257	18.0
82	8.0	160	14.3	260	18.1
90	8.8	170	14.8	270	18.4
92	9.0	175	15.0	280	18.8
100	9.8	180	15.2	286	19.0
102	10.0	190	15.6	290	19.1
110	10.8	200	16.0	300	19.5
113	11.0	210	16.3	310	19.8
120	11.6	220	16.7	316	20.0
124	12.0				

LUMBER FLUMES

FRANCIS R. STEEL

FLUMES are used very commonly in the Far West for the transportation of lumber from a saw-mill, located usually in the mountains, to the shipping point on a railroad or navigable waterway. In California, especially, this form of transportation is very common. Here the flumes average about five miles in length, with one, that of the Hume-Bennett Lumber Company, seventy miles long. The main advantages of this system as compared with railroad transportation — the only other possible method for large operations in the West — are: first, lower cost of construction (the difference increasing with the grade and the roughness of the country); and second, rather lower operation and maintenance cost. On the other hand, a flume cannot be run without a plentiful water supply, and it gives no means of transporting camp and mill supplies up to the woods. Then, too, in a flume operation the saw-mill must be located at some distance from the source of supplies, *i. e.* the railroad or the waterway, thus increasing the cost of sawing. Again, as the fluming roughens planed boards in such a way as to reduce their value, the planing mill must be located at a separate plant from the saw-mill. The same thing applies to the lumber yard, dry kilns, etc. Nevertheless, there are a great many situations where a flume is by far the most economical method of transportation.

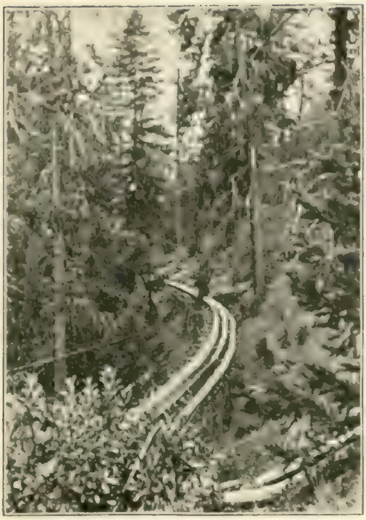
There are two main kinds of lumber flumes: first, the box flume, in which the trough is rectangular in cross section; and second the V-flume, in which the trough is V-shaped in cross section. This latter kind commonly, but not necessarily, has a "backbone" running lengthwise along the bottom, which makes a flat-bottom trough with outward slanting sides. Box flumes carry as a rule more water than V-flumes, and for this reason need to be built heavier and stronger, thus increasing the cost.

For ties a plain V-flume without "backbone" works the best, requiring less water, less watching, and costing less to build than either a box or backbone V-flume. For running boards and planks, as well as shingle bolts, etc., a box flume will, with plenty of water, transport a greater amount of lumber than any other type. For rather limited water supply, and to handle a mixed cut — both boards and dimension stuff — a backbone V-flume gives the most satisfactory service. The capacity of V-flumes is commonly from thirty to fifty M per day, while the maximum for this type so far is about one hundred M per day. Box flumes, however, are in use that carry as high as three hundred M per day — the lumber in this case being clamped together and dogged end to end.

A flume is located by an engineer in the same way that a railroad is. It is usually constructed from the upper end downwards in order to use the completed portion of the flume to transport lumber from the mill to the point of construction. The engineering costs usually about one hundred and forty dollars per mile and the construction, including labor, material, and right of way, varies from one to three thousand dollars per mile according to the height of trestles and depth of cuts necessary (a flume usually not having "cuts" of any depth, however, as they cost too much). The varying price of labor also affects the cost of construction. The safe maximum degree of curve has to be carefully determined in locating a flume, in the same way as with a railroad location. The following table has been given me by Mr. John P. Van Orsdel, a well-known logging engineer of Portland, Oregon.

Maximum Length of Lumber to be run	Safe Maximum Degree of Curve
40 feet	10 degrees
60 "	8 "
80 "	6 "
100–120 "	4 "

The safe maximum curve also varies with the per cent of grade. With a grade of over three per cent this factor may safely be neglected, but with grades under three per cent the safe maximum degree of curve diminishes rapidly with the per cent of grade.



Through fir timber

Riding the lumber

Trestle on a flume in Oregon

The following table is, I think, about right for the safe minimum grade.

Degree of Curve	Safe Minimum Grade
Straight	0.5%
4 degrees	1.0%
6 "	1.5%
8 "	2.0%
10 "	2.5%

The optimum grade for a flume is from three per cent up for a straight flume, and correspondingly higher on curves. There is practically no maximum limit of grade, as long as the upper and lower ends of the steep pitches are put in with vertical tapers. The Three Pines Lumber Company, in Oregon, successfully operates a twelve-mile flume with a maximum grade of about forty-five per cent.

In operating a flume the determining factor is the water supply. If this is unlimited, the flume can be run full continuously and lumber put in and " run " whenever desired. This is the easiest method of operation. After the lumber is put into the flume at the upper end it is watched on the way down by " flume runners " stationed on certain beats along the places where the lumber is most likely to " jam." These jams usually occur at the sharpest curves, especially if the grade at that place is too low (which sometimes cannot be avoided). Jams are also likely to occur where the transition from a high to a low grade is too abrupt. Running different widths and thicknesses of lumber together makes the run much more liable to jam than if the different sizes are taken down in separate runs. The flume runners usually carry " pickeroons " to enable them to handle the lumber more easily and quickly. The speed at which the lumber travels varies greatly with its size and shape, and with the grade of the flume. On steep pitches all lumber travels faster than the water, the ties and dimensions running faster than boards or plank. On low grades the reverse is true; the water runs away from the lumber and the small stuff goes better than ties or timbers. The behavior in the flume of the different classes of lumber run should be carefully studied for a given flume before determining the best method of running it. This is especially true when the

water supply is limited so that it is necessary to get out the greatest possible amount of lumber on the least water. This last matter too — the economy of water — will be greatly improved if the flume is kept in as nearly as possible water-tight condition. This will require pretty constant, although not expensive, repair work.

LAND SURVEYING IN FORESTRY

William Gibbs Howard, M. F. (Harvard) 1908

The importance of a knowledge of land surveying to the forester cannot be over estimated. In every branch of woods work surveying plays an important part, for an accurate survey is essential as a basis for the proper handling of any forest tract, be it large or small. It is obviously impossible to estimate timber without a more or less definite idea of area, both of the whole tract to be covered and of the various subdivisions which may be made to facilitate the estimate. The same principles are applicable in nearly all scientific forest work, either on a small scale, as in sample-plot or yield-table studies, or on a large scale, as in reconnoissance work.

That branch of surveying which deals with the re-location of old surveys and the retracing of lines run through the woods many years ago is a science in itself. The knowledge necessary to do this work well cannot be gained entirely from books. A man must have his book learning and his college engineering training supplemented by actual experience in the woods. I have seen township and lot lines run in the woods by a competent city surveyor. This man had had much experience in the city, but the lines which he marked out in the woods were in many cases several rods away from the true lines.

It is interesting to note the difference between the United States Government surveys in the West and the much older and more primitive surveys — some of them made in colonial times in the eastern states. Before going further I will state that my observations are based upon personal experiences, in the West in the Sierra Nevada mountains of California, and in the East in the Adirondack region of New York State.

The Government surveys of the West differ from the state or private surveys of the East in that they are much more regular and systematic. Let us compare the map of California with

that of New York. We see at a glance that in the western state base lines and reference meridians have been located to which the various township and section lines are referred. The whole state, with the exception of regions occupied by impassable mountain ranges, is divided into more or less regular rectangles. All lines are based upon the *true* north and south meridian.

In New York, on the other hand, the map is cut up by lines running in every direction. This is due to the fact that large grants of land were made to different persons, and these grants were sub-divided under different systems. All lines are referred to the *magnetic* north. Some of the meridians run north and south, while others — the so-called " ten o'clock " and " four o'clock " lines — run some thirty degrees east of north and west of south. This results in the large number of triangles and " gores " seen on the map. Inaccurate work by the original surveyors is the cause of irregularities both in the West and in the East.

Whatever the system of surveys under which the country was first laid out, the duty of the man in the field, who is trying to re-locate the old lines, is the same. That man must endeavor to reproduce on the ground the line of the original survey. It matters not if that survey was carelessly run out and the corners wrongly set. If the original line blazes and corner monuments can be found, they serve to definitely locate the old survey.

The graft which existed in some of the United States Government surveys is a matter of history, and it is well known that there are thousands of acres of land in California that were never surveyed on the ground at all. Field notes were " faked " and maps made in the city of San Francisco. However, where the lines were run out in the field they were usually run by transit and the corners fairly well monumented and witnessed. It may be noted here that the government surveyors in the West paid most of their attention to marking the corners, while the lines between the corners were only marked at infrequent intervals. In the old Adirondack surveys, on the contrary, the lines were carefully marked out, while the corners were merely marked on trees or wooden stakes which soon decayed.

As a rule, the government survey corner consists of either a squared stake surrounded by a pile of stones, or a square stone

with or without other stones around it. In the case of township or section corners there are four witness trees, one in each quadrant around the corner. Each witness tree bears a blaze facing in towards the corner, and the number of the section in which the tree stands is scribed in the blaze. In the case of quarter-section corners there are two witness trees, one in each section bounded by the line in which the corner stands. The original field notes contain the distance and direction from the corner to the various witness trees. In case the corner has been destroyed or overgrown with vegetation, its position can be determined from the witness trees.

The corners of the old Adirondack surveys consist usually of stakes or standing trees blazed on four sides and scribed with the proper township and lot numbers. From two to six witness trees are marked. The witness mark is three horizontal notches one above another close to the ground, and facing in towards the corner. The old field notes seldom refer to the witness trees.

The best instrument for retracing the government survey lines is a light mountain-transit. Copies of the field notes of the original survey should be obtained and the course of the line to be run computed. The start must, of course, be made from a corner the location of which has been previously ascertained. A random line should be run on the computed course as far as the next section corner. The proper correction must then be calculated from the length of the line as chained and the length of the right angle offset from the line to the corner, and the true line run out and properly marked. If original line trees are found between the two corners, the true line should be made to run through or near them, even though this may mean substituting a crooked line for a straight one. This matter will be taken up more in detail in the discussion of Adirondack lines.

The problem of retracing a line in the Adirondack forests is somewhat different. In the first place, a compass is more suitable for this work than a transit. Either the so-called "Pocket Vernier Compass" ($4\frac{1}{2}''$ needle) or the "Railroad Compass," both manufactured by W. & L. E. Gurley, are satisfactory instruments. They may be used with jacob's-staff or tripod.

Let us suppose a surveyor wishes to retrace the lines of a lot

in the woods, one side of which is in the township line. He should start his survey at one of the two corners in the township line, and we will suppose that he knows the location of one of these corners. Since the lines are run on magnetic bearings very little computation is necessary to calculate the course of the line. The original bearing and the date of the original survey known, it is a simple matter to determine the present bearing of the line. In the Adirondack region the magnetic variation has been increasing at the rate of about three minutes a year for the last one hundred and fifty years, and as a compass is to be used it is sufficient to calculate the bearing of the line to the nearest fifteen minutes.

The compass is set up at the starting point, and the correct course of the line, as calculated, turned off. So far the procedure has not differed materially from that followed in running out the lines of a city lot; but from now on the surveyor will need to call upon his knowledge of woodsmanship for guidance. He must examine every tree along the line to locate the original line trees. The line which he wishes to follow has probably been surveyed several times. Some of the newer lines have been blazed by lumbermen who merely followed through from corner to corner with a pocket-compass and marked convenient trees. The task of our surveyor is to distinguish the blazes of the first surveyor from amongst the maze of newer blazes. In the case of a line surveyed a hundred years or more ago this requires a sharp eye and a knowledge of what a very old blaze looks like. In our north woods forests the spruces and the hemlocks show plainest the marks of the old surveys. I have cut into trees of these species and found blazes a hundred and thirteen years old. The only sign of a blaze on the outside of the bark was a slight irregularity in the surface, which upon minute examination showed the mark of an axe blade. Of the hardwoods, the birches show the old marks the best. The maples and beeches are the worst trees of all in this respect. Even on the birches it is difficult to discover a very old mark. The mark is often more easily distinguished when one is fifteen or twenty feet away from the tree than when one examines the bark closely. I once found a blaze one hundred and ten years old on a birch

tree by standing some distance away from the tree and directing my axeman to move his hand up and down the trunk until he covered the mark. From where the axeman stood the mark was not distinguishable; but upon chopping into the tree we found the blaze about four inches beneath the surface of the bark.

When the surveyor comes upon a tree which he thinks bears the original blazes he should chop out a blaze and count the number of annual rings formed since it was made. In this way he can ascertain the exact year of the survey of which that blaze is a mark; and by reference to his field notes he can tell whether or not that is the original survey. In retracing these old lines care should be taken to note the chainage from the corner to each line tree. After a few of the original blazes have been chopped out the surveyor will find that he can distinguish them from the newer marks by their external appearances.

It frequently happens that a line run on the computed course swings away from the old line after following it for a short distance. If the surveyor finds that this is the case he should offset at right-angles and set up as nearly as possible on the old line. He should mark his trial line plainly by stakes, but should not mark any trees if he can avoid it. When he has run his trial line through to the next corner he must go back and mark the correct line, following as nearly as possible the line of the original trees.

The line as finally marked will oftentimes be far from straight. Most of the old surveys were run without regard to any local attraction of the compass needle. The compassman would sight ahead and locate a tree in line; then he would pick up his compass and walk up to that tree, setting up again on the farther side of it. The chainmen and axemen followed him, the latter marking out the line. Unless the local attraction was very strong indeed no backsights were taken. The result was that, where there were only a few degrees of local attraction, the line would swing around in a large arc, resuming the proper course after the area of " local " was passed.

It is of the utmost importance to endeavor to find some trace of the original corner or its witness trees. The latter will often be found lying half rotten upon the ground; but by examining

them closely one can usually find the old marks even though they be hidden under the moss and decayed wood. In case all marks of the original corner are missing, the surveyor must re-locate the corner. He will frequently be able to fix its position by prolonging the four lot lines until they intersect. It sometimes happens that all four lines have to be entirely re-run and chained in order that the location of the corner may be definitely established. I have known a competent wood surveyor to spend two days in locating the corner from which he wished to start his survey.

One thing which the surveyor should bear in mind is the importance of marking his lines and corners in a plain and permanent manner. Line trees should be blazed at frequent intervals. Corners should be clearly witnessed, and the corner monument should contain two or three stones if there is any rock within reach.

In the foregoing lines I have tried to give an idea of a few of the problems which the woods surveyor must prepare to meet when he goes out into the field. His task may seem difficult, but when he thinks of the men who went over the same ground a century or more ago, he is bound to be infused with the spirit of those men who went out fearlessly to do their work in what was then a vast wilderness. The field notes of some of the old surveys make interesting reading, and show us some of the difficulties and dangers encountered by the men in the field. It is to perpetuate their work that we are sending our surveyors into the woods today.

A FOREST FIRE WAGON FOR MASSACHUSETTS TOWNS

Harold O. Cook, M. F. (Harvard) 1907

Last spring the Legislature passed a bill which provided that if any town having a valuation of less than one and one half millions of dollars should appropriate a sum, not exceeding $500, to purchase forest fire equipment approved by the State Forester, the Commonwealth would pay back to the town fifty per cent of the amount spent. The reimbursement being conditioned on the approval of the State Forester, it was necessary for him to make plain what he considered an ideal or standard outfit for such a purpose. Fortunately two years previously this office made a study of the subject of forest fire fighting and the equipment used for this purpose in such towns as employed anything of the kind. This study showed that there were certain essential elements in the make-up of a successful fire fighting machine and that it was only necessary to combine these in the proper way, add a few improvements looking to convenient and quick handling, and obtain an ideal forest fire fighting equipment. These elements were a good strong wagon, chemical fire extinguishers, cans for holding water, spare chemical charges, rakes, shovels, mattocks, axes, etc.

This office has had built two model wagons, one designed for two horses and to carry six or eight men, and a one-horse outfit carrying three or four men. The larger wagon cost, with the equipment, $500 and the smaller $300. The two-horse wagon is cut-under, mounted on platform springs, rigid body, and has wide-tired savin wheels. It is the finest type made by wagon builders and with the addition of some fancy metal work and gold paint would equal a hose wagon in a city fire department. Fourteen chemical extinguishers are placed in racks along the sides so that they cannot tip over. At the back on each corner

are two cases containing six removable drawers with bail handles. These drawers contain the spare chemical charges, the acid being in bottles already to slip into the extinguisher and the soda in cans, one charge to a can. About eighty spare charges are carried in this way. Underneath the body of the wagon are two racks, each holding five shovels and three rakes. The body of the wagon is occupied by fourteen five-gallon galvanized iron cans, each can holding water enough to refill an extinguisher twice, so that each of the extinguishers can be used three times before it is necessary to send for more water. These cans have bail handles so that they can be carried by one or two men and the stopper is so devised that two bottles of acid can be inserted in it. By having the soda already mixed with the water everything is complete in each can to refill the extinguishers, an important improvement when it becomes necessary to carry them for a distance into the woods. There are also on the wagon two kerosene sprayers which are useful in starting back fires. These are carried under the seat together with the grub-hoes and six pails. On the sides of the wagon are two axes and two fire department lanterns.

The single-horse wagon is cut-under but has semi-elliptical instead of platform springs. The spare chemical charges are carried in drawers under the seat. It has all the equipment of the larger wagon, but about one third less in amount and was designed to accommodate communities where it might not be easy to get hold of a pair of horses.

Towns where an equipment of this nature has been in use for some time are enthusiastic in their praise and are buying more. By adding a small extension ladder to the equipment they have been able to use it at building fires as well as at forest fires. Such a wagon takes the place of the chemical engine in the city which puts out the blaze of three quarters of the alarms that are rung in. To a town without water service it is indispensable, and it is a valuable piece of equipment to any community looking at it from the standpoint of building fires alone, whereas for forest fires, it is the only practical outfit that a town can secure.

SOME PRELIMINARY INVESTIGATIONS CONCERNING THE RATIO BETWEEN *DBH* AND *DIB* AT STUMP FOR WHITE PINE IN MASSACHUSETTS

Harry F. Gould, M. F. (Harvard) 1908

The purpose of the work described below was to obtain from data already at hand in the State Forester's Office a reasonably correct table giving the DIB–DBH ratios for different sized trees of the species White Pine (*Pinus strobus*).

The usefulness of such a table is apparent in many instances. Whereas volume tables are almost without exception constructed on a DBH basis, yet many cases come within the timber estimator's experience where he cannot obtain the DBH directly. Such a situation is more likely than not to exist when the estimator is called upon to decide a lawsuit. The chances are that the timber has been cut and removed, leaving only the stumps to go by in taking measurements.

Then there is the case of suit for trespass where the owner claims timber to have been unlawfully removed; to say nothing of fire damage which may require immediate cutting of the dead trees and so make it impossible to measure DBH directly.

The table given herewith was prepared from data obtained in various sections of Massachusetts by measuring representative stands of pine and is recommended for use in this state only, inasmuch as foresters are becoming more and more convinced of the impropriety of generalizing data and trying to apply it over too large a territory.

One hundred and eighty-eight trees were used, ranging in diameter from 6 inches to 35 inches, and these were separated into stump-height classes of 6 inches (76 trees), 12 inches (75 trees), and 18 inches (37 trees). The points were then plotted on cross-section paper and three curves drawn through them, one for each stump height.

The table was made by reading the values from these curves using the DIB as a basis, since this forms the most useful table.

In its final form, then, the table indicates for each of the three stump-height classes the number of inches to be subtracted from a given DIB to give the desired corresponding DBH.

Several suppositions which common sense leads us to suspect but which are not otherwise proved are shown by this table to be true:—

1st. The lower the stump the greater the DIB–DBH difference, for a given diameter.

2d. The larger the diameter, the more rapid the increase in DIB–DBH difference for a given stump height, after 12 inches DBH has been exceeded.

And another point which is not quite so evident, following from the above:—

The *increase* in the DIB DBH difference for trees of from 4 inches to 12 inches DBH is practically 0, whether for a 6-inch or a 12-inch stump.

Another interesting fact shown by the curves though not by the table is that there is much greater conformity to these curves among individual trees than might be supposed, the variation being scarcely over 5% for any given tree.

It is hoped that in future further data will be obtained which may serve as a check on the figures given in the table, which follows:—

Stump height	DIB at stump																												
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	Amount to be subtracted to get DBH for each DIB corresponding																												
6″	2	2	2	2	2	2	2	2	2	2.1	2.2	2.2	2.3	2.4	2.5	2.6													
12″	1	1	1	1	1	1	1	1	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.1	2.3	2.5	2.7	3							
18″											.2	.3	.4	.5	.6	.8	1	1.2	1.4	1.6	1.8	2	2.3	2.6	2.9	[illegible]	[illegible]	3.8	4.2

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A VOLUME TABLE FOR RED MAPLE ON THE HARVARD FOREST

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Red Maple (*Acer rubrum*) is the most important of the trees cut for cordwood on the Harvard Forest. More than half of the total cut of fuel wood, and more than seventy-five per cent of the " hardwood " is of this species. Of the trees used primarily for fuel, only gray birch (*Betula populifolia*) approaches it in numbers in the Forest, and the small size of the birch makes insignificant its proportion of the total volume cut.

The maple is present on nearly every wooded acre within the Forest. The heaviest stands are in the hollows or swales where the ground is moist, but not swampy. On such situations small stands of nearly pure red maple may be found, with only a scattering mixture of other species such as white elm (*Ulmus americana*), chestnut (*Castanea dentata*), black cherry (*Prunus serotina*), white ash (*Fraximus americana*), and yellow birch (*Betula lutea*). Here the tree reaches its best development for cordwood, the usually dense stand forcing height growth to an extent that produces trees eighty to ninety feet tall, and with few large limbs. Stands of forty to fifty cords per acre are not uncommon.

In the swamps, maple occurs in mixture with red spruce (*Picea rubens*), hemlock (*Tsuga canadensis*), tamarack (*Larix laricina*), and tupelo (*Nyssa sylvatica*). On such situations the maple has a relatively poor form, caused by the poor soil and the bad treatment of the forest in the past. The trees are short, often unsound, and usually very limby or forked. As a rule the stand of cordwood is not heavy. The same poor form is found in some swales where past logging opened the stand and caused the development of heavy crowns with forked and branchy stems.

On the slopes and ridges maple, although practically always present, is a much less important member of the tree community. Here white pine (*Pinus strobus*) is the most abundant species,

although on some slopes chestnut, red oak (*Quercus rubra*), and other broadleaf species form the stand. In either case, the maple is numerically unimportant, usually occurs as single trees, and is usually removed in thinning, that the saw-timber species may be benefited. Only on those slopes and ridges which were cut clean twenty years ago is the maple considered to be a valuable species and there only because it is a better tree than the gray birch, which occupies most of the ground.

The low price of red maple boards, the frequence of the defect known as "black heart" and the heavy weight of the logs and lumber make it unusual for even a good sized tree of this species to yield saw logs which can be handled at a profit in this region. In estimating, maple of any size not too large to be split without powder is usually classed as cordwood. On the Harvard Forest, red maples larger than fifteen inches D B H are infrequent, and up to that size the choppers have little difficulty in splitting the butt cuts with wedges.

The importance of the species in the operation of the Forest led to the collection by the classes of 1912 and 1913, Harvard Forest School, of the data here presented. Most of the trees were cut by the students, but some were measured after being felled by the wood-choppers. The measurements taken on each tree were the D B H, the total height, and the mid D O B of each length of merchantable cordwood, stem and limb wood being recorded separately. The crown class of each tree, and the type in which it stood were also recorded. The number of trees measured is insufficient to give reliable results when considered for the relations of volume to crown class, or type, or for the relation of limb wood to stem wood. It is hoped to develop these relations through additional data.

Every care was taken to make the measurements represent the utilization customary in the vicinity. As a rule, bolts larger than eight inches in diameter were measured exactly four feet in length, since sticks larger than this diameter are ordinarily cut with a saw. Bolts smaller than eight inches were allowed a length of 4.2 feet, since they are usually cut with an axe, but were cubed as four foot sticks. Limbs and tops were considered merchantable whenever a four foot stick with a mid D O B of two inches or more could be

Table I

TABULATION OF DATA FOR VOLUME TABLE FOR RED MAPLE

Based on Measurements taken in 1910 and 1911 in Harvard Forest, Petersham, Mass.

D B H inches	Total Height in Feet: 25	30	35	40*	50	60	70	80	90	[illegible]
	Average Merchantable Volume in Cubic Feet									
2	.251 27	.394 15	.414 2							44
3	.588 4	.698 20	.819 13	.932 12	1.382 5					46
4	4.0 1.028 1	4.2 1.320 1	1.210 7	1.349 10	2.115 13					27
5			1.913 6	2.314 15	3.120 12	3.787 7				34
6			6.2 3.381 2	3.530 15	4.501 11	5.006 10	6.484 2			38
7				4.617 2	6.376 4	7.678 8	8.358 6			20
8				6.694 2	7.933 6	9.035 12	10.241 11	8.3 13.048 1		32
9				9.5 8.504 1	10.305 5	13.269 3	14.832 [illegible]	13.904 [illegible]		24
10					10.1 13.168 1	16.324 4	15.554 5	10.3 20.364 1		11
11					17.396 4	19.616 3	20.502 7	21.147 4		18
12						21.292 2	26.022 2	30.306 2		6
13					12.6 23.200 1		12.6 22.368 1	12.6 33.048 1		3
14						14.2 31.930 1	14.0 31.668 1		14.2 43.684 1	3
15								14.6 39.896 1		1
16						16.0 47.708 1		16.0 47.032 1		2
17								17.1 59.398 2		2

Total number of Trees 311

* This class includes all trees 35.1 feet to 45.0 feet in height, and therefore some trees below 7 inches D B H which were also used in computing the averages for the 35 foot class. The averages for the trees 37.6 feet to 45.0 feet in height were as follows:

D B H	Volume
3	.958 4
4	1.443
5	2.581
6	3.545

secured, but here again the usual tendency of choppers to disregard possible lengths from the limbs of large trees and to use tops and limbs of small trees to somewhat less than two inches was followed.

As may be inferred from the wide range of heights for each diameter below fourteen inches (see Table I), measurements were taken in many places and in a wide variety of types, including bottom or swale, pine slope, swamp, and birch and maple coppice. Most of the trees more than six inches D B H were of seedling origin.

The volume of each tree was determined by computing the volume of each bolt by Huber's formula ($B\frac{1}{2} \times L$) and then adding the volumes of the several bolts. The volumes of trees with the same D B H and height were then averaged. These computations were checked, and partially rechecked. The averages were then tabulated with the number of trees averaged indicated by a small figure below and to the right of the figure for the volume, and when there was but one tree, the diameter shown by small figures above and to the left. Thus ${}^{10.1}13.168_1$ indicates that there was one tree of a certain diameter class and height class, the exact diameter being 10.1 inches and the volume 13.168 cubic feet.

The irregularities in the foregoing table are numerous, especially in the higher diameters in which few trees were secured. To remove these irregularities the data was plotted on cross section paper, and a curve drawn for each height class showing the volumes of trees of different diameters within that height class. In entering the data, the notation of the actual diameter of the single trees which were secured for some diameters enabled accurate plotting to be done, and the number of trees averaged to give the volumes was entered in each case so that due weight could be given in drawing the curves. The results showed some irregularities still present, especially in the seventy foot height class. The corrected data were again plotted so that a curve could be drawn for each diameter class showing the volumes of trees of different heights, and the readings from these curves were again plotted and a new curve for each height class drawn, superseding the first set of curves. The resulting readings are given in Table II.

The volumes for trees in the two inch D B H class are so small, and the habits of wood choppers in cutting up such small trees

are so irregular that this diameter class was dropped from further consideration. In estimating, the possible amount of wood from trees less than 2.5 inches D B H can be considered as a margin toward conservatism.

Purely as a check on the work done so far, the volumes given in Table II were used in computing a table of merchantable form

TABLE II

VOLUME TABLE FOR RED MAPLE IN CUBIC FEET

Harvard Forest, Petersham, Mass., 1910–11

D B H inches	Total Height in Feet								
	25	30	35	40	50	60	70	80	90
	Merchantable Volume in Cubic Feet								
2	.25	.4	.5						
3	.6	.7	.8	.9	1.3				
4	1.0	1.15	1.25	1.5	2.1				
5			1.95	2.3	3.1	3.9			
6			3.0	3.5	4.4	5.2	6.5		
7				4.8	5.9	7.0	8.2	9.4	
8				6.4	7.9	9.1	10.5	11.6	
9				8.1	10.3	11.8	13.2	14.4	
10					13.1	15.0	16.5	17.6	
11					16.6	18.4	20.2	21.5	
12					20.7	22.3	24.2	25.8	
13					25.2	26.5	28.7	30.8	
14					30.0	31.2	33.7	36.5	41.5
15						36.0	39.1	43.0	
16						41.5	45.0	50.5	
17								58.0	

factors (see Table III), since it was thought that in this way any large errors would become apparent. The form factors proved to be surprisingly regular except for the larger diameters in the fifty foot height class. No adequate explanation of the high values in these cases can be given. At eleven inches, the form factor is above 500, but the average form factor for the four trees of this diameter and height actually measured is 527. More data must be collected before the results for the diameters above nine inches in the fifty foot height class can be accepted without caution, or completely rejected.

The next step in the preparation of the volume table is based on admittedly scanty data. An attempt was made to secure average figures for the proportion of wood in piles each containing the bolts from trees of one diameter class. Ordinary commercial practice was followed in splitting large bolts. Measurements of only nine piles were taken, but the resulting averages, curved, are at least

TABLE III

TABLE OF FORM FACTORS FOR RED MAPLE

Harvard Forest, Petersham Mass., 1910-11

D B H inches	Total Height in Feet								
	25	30	35	40	50	60	70	80	90
	Merchantable Form Factors								
3	464	453	457	459	530				
4	477	438	411	429	481				
5			429	420	454	476			
6			437	446	448	442	473		
7				449	441	436	438	439	
8				458	453	434	421	415	
9				458	466	446	427	407	
10					480	458	432	403	
11					503	465	437	407	
12					527	473	440	411	
13					547	479	445	418	
14					561	486	450	427	431
15						489	455	438	
16						495	465	452	
17								460	

approximately correct for average conditions on the Harvard Forest. The influence of crown class was found to be very strong in even the small amount of work done, since overtopped and intermediate trees usually have few limbs and the bolts are fairly smooth, while dominant trees often have heavy crowns which yield knotty and crooked bolts. One pile made from overtopped six inch trees had over seventy per cent wood, although the average for this diameter was well below sixty per cent. In estimating, this variation should be kept in mind, especially where suppressed or intermediate maples are to be taken out of a pine or chestnut stand in thinning. The proportions used are given in Table IV.

TABLE IV

PER CENT OF WOOD IN PILES OF RED MAPLE CORDWOOD

Based on 9 piles of 2 to 4 cord feet each. Harvard Forest, Petersham, Mass., 1910–11

D B H of Trees	Per cent of Wood in Pile	D B H of Trees	Per cent of Wood in Pile
3	52.5	11	68.0
4	53.6	12	70.0
5	54.9	13	71.5
6	56.2	14	73.0
7	58.0	15	74.0
8	60.2	16	74.6
9	62.8	17	75.0
10	65.5		

TABLE V

VOLUME TABLE FOR RED MAPLE IN CORDS*

Based on Measurements taken in 1910 and 1911. Harvard Forest, Petersham, Mass.

D B H inches	Total Height in Feet									Basis No. of Trees
	25	30	35	40	50	60	70	80	90	
	Merchantable Volume in Cords									
3	.009	.010	.012	.013	.019					46
4	.014	.016	.018	.022	.030					27
5			.028	.033	.044	.055				34
6			.042	.049	.061	.072	.090			38
7				.065	.079	.094	.110	.127		20
8				.083	.102	.118	.136	.150		32
9				.101	.128	.147	.164	.179		24
10					.156	.179	.197	.210		11
11					.191	.211	.232	.247		18
12					.230	.241	.270	.288		6
13					.275	.290	.314	.336		3
14					.321	.334	.359	.391	.444	3
15						.380	.413	.455		1
16						.434	.471	.529		2
17								.604		2
									Total,	267

* This volume table is computed with the standard cord of 128 cubic feet. In places where extra height is required to allow for shrinkage, the volumes given should be reduced proportionally.

The cubic volume for trees of each diameter and height class given in Table II was then divided by the percentage for the corresponding diameter class given in Table IV, and the quotients multiplied by 100 to find the space, in cubic feet, occupied by the tree in a pile. This figure was again divided by 128, and the quotient taken as the fraction of a cord of merchantable wood in the tree. The volume table was then rewritten in cord measure, and is given as Table V.

The custom on the Harvard Forest is to measure cordwood promptly after it is cut, using as the unit of measure the standard cord (a pile four feet wide, four feet high and eight feet long), containing 128 cubic feet. The wood is usually sold without remeasurement. The foregoing table has been made for use under these conditions, and the volumes given should be discounted for use in localities where choppers are required to make their piles four feet four inches high to allow for shrinkage. This discount may also be made by using the table as it is, but reducing the total indicated volume of the stand. A discount of ten per cent would be liberal, and eight per cent should ordinarily be sufficient.

Possibly the following general statement may be remembered for use when the table is not at hand.

Red maples of good height for their diameters should run: —

If	4	inches	D B H	about	50	trees	to	the	cord.
If	6	"	"	"	20	"	"	"	"
If	8	"	"	"	9	"	"	"	"
If	10	"	"	"	6	"	"	"	"
If	12	"	"	"	4	"	"	"	"
If	14	"	"	"	3	"	"	"	"

FIRE PROTECTION

RICHARD F. HAMMATT, B.S.F. 1906

SOME six years' work, mostly administrative, in the United States Forest Service, has impressed me more and more with the vital importance of the fire problem, particularly from the lumberman's and forester's view points.

To the progressive lumber or pulp concern, or the forester going into either private or Government administrative work, fire protection is, in a way, the basis of all operations. What concern can hope to get a second cut from its logged over lands, if they are burned over every five or ten years? What good does it do for the forester to determine quality classes or rate of growth, to figure on yield per acre, rotation, or annual cut, if continued fires are going to upset all his calculations and burn all his work? The prospective forester *must* understand that it is up to *him* to so protect the holdings in which he is working that his other work will be of some value.

There are now a number of schools and colleges in the United States giving instruction in lumbering and forestry. There are, annually a large number of men attending such schools. Do these men realize how much more true fire protection means than getting men, supplies and tools to a fire as soon as it is reported, and then putting it out? Did it ever occur to you that, as the man in charge, you should know, not only every square mile of the physical features of your country, but that you should know, too, the climatic, moisture and wind conditions, and the amounts and kind of brush and debris as well as the timber?

Nearly every one realizes, of course, that time, money, and loss of life and property can be avoided by roads, trails, and telephone lines. Did you ever try to work out a complete and *economical* plan for such improvements covering a broken area of one and one-half million acres? You know that to get the fullest benefit from such a system there must be a force of men placed at strategic points throughout the dangerous season. Did you ever try to pick

out such places over a big area ? And did you ever plot and compare curves showing the area burned over per week throughout the fire season, the number of fires per week of the season, and the number of men per week of the season necessary to give the proper protection, and at the same time keep costs to a practical minimum ?

Fire protection is undoubtedly a big and vital question, so vital that more time should be given to it in schools and colleges than has been done in the past. It is true that *fire fighting* cannot be taught. But fire fighting is secondary to fire protection and fire prevention and to a large extent these can be taught.

In any course on fire protection, prevention should also be considered. Fire prevention is largely a question of publicity, organization, personality and legislation.

No matter how good the local or national legislation is, it may be practically nullified unless the public is brought into sympathy with the objects sought. This can best be done with local residents by personal contact, and with other users of a forest area by publicity. We should all recognize the fact that we must get the public interested in our work. To do this, interesting and instructive articles and so called news items must be prepared. The importance of this phase of the work should not be overlooked.

In fire protection much preliminary work is necessary. Fortunately the members of the Harvard (and several other) schools should have, by now, much of the preliminary data.

There is required, first, as intimate a knowledge as is possible of the area to be protected, its topography, climate, prevailing winds, moisture conditions, forest conditions (including brush, debris, especially valuable sub areas, etc.), its existing roads, trails, railroads, telephone lines, towns, lumber, and other camps and ranches; the principal area used by campers, hunters, and fishermen, and the main routes used by them in entering and leaving the area under consideration.

In addition there should be obtained a history of recent fires, their location, area, causes, damage done, and methods and cost of fighting them. This information should be tabulated and summarized. As much of this information as is possible should be shown on a topographic base map of the area.

Right here should be emphasized the necessity, (*first*) for careful and detailed plans and, (*second*) the putting of those plans on paper. The man who doesn't plan this part of his work carefully and thoroughly ought to be given a job requiring a strong back and a weak mind, rather than vice versa. And the man who, knowing that he personally can't see to all the details of every emergency that may arise, doesn't, after making them, put his plans on paper, should be treated only a little more leniently than the first man.

All this, and much more information is but preliminary to the actual plan. Next should come the determination of the number of men needed to insure protection, the points at which they should be placed and the lengths of time they should be employed. Will a system of stationary lookouts on high and commanding peaks serve, or do you need mounted patrolmen? Should you have a combination of the two or do you need moving lookouts? Should the patrolmen stick to the ridges in order to see over a big country or should they be in the main-used canyons and on the main-travelled roads and trails to keep track of hunters, campers, and fishermen? Have you got commanding peaks or ridges that can be used or trails that will allow patrols to travel in the right places? Shall the patrols go on foot, horseback, or should they use motor-cycles or automobiles? When does the fire season begin — when does it end — and what is the most dangerous season? Which will give you the best protection, ten men from the beginning to the end of the season (say five months) at a total cost of $3750.00 or one man for five months, two for four months, six for three months, nine for two months, and one for one month. In the second case it is quite probable that you are getting better protection with the same amount of money by employing twenty men for short periods instead of ten men for longer periods. On the other hand, it may be possible that conditions are such that a number of comparatively long term men must be employed.

If lookouts are used there must be means of quick transmission of messages, either telephone, telegraph, heliographs or a wig wag system. The patrols should be able to get messages to headquarters quickly and they must be able either to get men and supplies themselves or have them sent in without delay. What methods of communication are available and what more are

essential? When should they be built and will their cost pay in the long run? Have you made arrangements for the lookouts to live on top of the peaks or will they camp below somewhere where they will lose two hours through the day and all the evening, night, and early morning?

It is essential that your patrols keep as much as possible in touch with headquarters, and you or some one, should know where to get them at any time of the day or night. Are they travelling their particular country promiscuously or have you laid out for them definite routes, with schedules, so you will know where to intercept them if necessary?

Does each man of your protective force (outside of the stationary lookouts) know where he can get men, tools and supplies quickest for any fire that may occur? How is he to provide transportation? Is there a store at which provisions can be obtained and does he know how many provisions to take without packing an extra 100 or 200 pounds? How many extra men can he get, where can he get them, and how soon can they reach the fire, if it is a big one and he needs a big force?

These are a few of the questions which nearly every one of you will have to consider. The answers will be different in nearly every case, but if you will consider the problem for a given area now, it will help immensely when you start out into actual work of your own.

NOTES ON THE CHESTNUT BARK DISEASE (*DIAPORTHE PARASITICA*, MURRILL) IN PETERSHAM, MASS.

J. Kittredge, Jr., 1913

The following data were collected in October and November, 1912, at Petersham, Massachusetts. The object of the study was to determine the present status of the chestnut bark disease in and about the Harvard Forest and to secure any possible information about the habits and appearance of the fungus which might indicate the means by which it is or is not distributed.

The disease was first noticed in Petersham in the fall of 1910 by Professor J. G. Jack of the Harvard Forest School, along a road not over a mile from the School and about three and one-half miles north of the village of Petersham. In August and September, 1911, Professor A. H. Graves, then in the Bureau of Plant Industry, found infection at several places in and about Petersham, particularly along the Athol Road. At that time he marked infected trees in several localities and carefully examined others near them, noting whether they were probably infected or apparently sound. The locations of a number of these infectious were pointed out to the writer by Professor E. E. Carter of the Forest School.

In this study the infection was viewed from the forester's standpoint, with little or no reference to the morphological or physiological characteristics of the disease. At the time of the study, only the winter fruiting bodies were in evidence.

In the first part of the study, data was collected as follows: All trees showing any evidence of infection were first classified in three groups: —

I. Trees surely infected (with the fruiting bodies developed).

II. Trees probably infected (with dead branches and persistent dead leaves or burrs or badly sunken bark).

III. Suspicious trees (with the persistent leaves or sunken bark less markedly developed than for Class II trees).

Trees which were apparently uninfected were entirely disregarded. For all trees included in the above tree classes, the following data was noted: —

1. Careful geographical location.
2. Origin, seedling or sprout.
3. Diameter at breast height.
4. Crown class; whether dominant, co-dominant, intermediate, overtopped, or suppressed.
5. Distribution of infection about known centres, and relations of crown and distance between infected specimens (numbered and oriented sketches).
6. Location of trees relative to site, aspect, forest type, and density of surrounding stand or degree of isolation with history of its cause.
7. Probable length of time since infection started.

The field work consisted in the inspection of trees, along roads, on strips through the woods, and around infections which had been previously reported. After some data had been secured in this way, the rest of the time was devoted to a detailed study of one stand on the Harvard Forest, which will be described later.

The infection is now almost universally distributed in the town of Petersham. Surely infected trees were found from the Athol line on the north to North Dana and New Salem on the west, and two miles south of the village toward Barre. The region to the east of the village was not examined.

Origin seems to have had no effect on the susceptibility of chestnut to the disease. The data obtained showed that the total number of infected sprouts in Classes I and II exceeded the total number of infected seedlings in the ratio of two and one-half to one, but this difference is easily accounted for by the predominance of sprouts over seedlings in the whole chestnut growth of the region. When all trees are included as a basis of comparison, the ratio is about three and one-half to one. This is, however, in a stand typically of sprout origin. On the special plot, the insignificance of the influence of origin is more evident, for of 219 trees of seedling origin, 32 (14.5 per cent) were surely infected, and of 747 trees of sprout origin, 97 (13 per cent) were surely infected. Trees in Classes II and III have been omitted from consideration

here because they were so numerous in this stand, where so many sources of infection were in close proximity that origin could have no effect on their susceptibility in any case.

Proximity to roads and highways has no apparent effect on the distribution of the disease. It occurs right next to the roads on isolated roadside trees, but on the other hand, the worst infection examined was more than one-quarter of a mile from any road and fully a mile from the nearest highway used by automobiles. Whole stands, more isolated from roads than this one, are rare in the vicinity.

The relation of appearance of fruiting bodies to side of trees was also studied. When the infection is three or sometimes only two years old, it has almost always girdled the tree, so that the fruiting bodies appear on all sides of the stem. If, however, the infection is more recent, they usually appear on the south or southwest side of the tree, probably owing to the greater warmth of the sun's rays on that side. In two cases where the trees were heavily shaded to the S. W., the fruiting bodies were observed only on the unshaded N. E. side. Of 112 trees, showing the fruiting bodies only on one side, the different sides were represented as follows: —

	S. or S W	N	E	W.	Total
Number of trees	93	3	5	11	112
Percentage of total	83	3	4	10	100

Grouping the trees noted in three inch diameter classes, it appears that trees from three to six inches D B H show at least the matured results of infection quickest and that trees below six inches are more liable to infection than those of larger diameter. The figures somewhat exaggerate the actual conditions owing to the predominance of the number of small trees among those examined, but the numerical ratio of small to large infected trees appears distinctly larger than the ratio of all small chestnuts to larger ones on the areas examined.

The fungus will as readily attack a healthy dominant tree as a feeble suppressed one. Frequent cases were noted in which trees grown in the open pasture lands or along roadsides bordered by

meadows, under the best light conditions for vigorous and complete crown development, were badly attacked. The figures seem even to indicate that it prefers the dominant trees, for of the 231 surely infected trees, sixty-three per cent were dominant or co-dominant, seventeen per cent were intermediate, and twenty per cent were over overtopped or suppressed; and of the 524

INFECTION BY DIAMETER CLASSES

Diameter Class	Surely Infected		Probably Infected	
Inches	Number	Per cent	Number	Per cent
0 –3	59	26	261	50
3 –6	106	46	223	42.5
6 –9	52	22	33	6
9–12	11	5	5	1
Over 12	3	1	2	0.5
Totals	231	100	524	100.0

probably infected trees, forty-three per cent were dominant or co-dominant, twenty-three per cent were intermediate, and thirty-four per cent were overtopped or suppressed.

No consistent relation between centres of infection and more recent infection from those centres could be established, although it was very evident that some areas were more heavily infected than others. Descriptions of the distribution about two rather distinct centres will best illustrate the lack of a definite relation as to direction.

1. A seed tree left on flat after cutting in 1909; now badly infected and dying. There is an alder swamp to the west and three year old sprouts over the open country to the S. E., and N. W. Three surely infected sprouts, which might under the circumstances have been infected by wind dissemination from this tree, are situated, (*a*) 45′ north, (*b*) 50′ east, and (*c*) 115′ S. E. There is probable infection scattered over much of the area.

2. Another flat, three hundred yards northeast of the first one. A mixed hardwood and pine stand which had been thinned and was surrounded by pure pine and swale. This case shows a distribution about centres to the W., S. W., and N.

In neither case is there any possibility that the spores could have washed from the central tree to the others. The diseased trees on the special plot show further examples of centres and the surrounding infection with no constant relation between the two. Certainly in these cases, with the possible exception of the first one, there is no distinct spread to the N. E. or S. E. as might be expected if the fungus spores were primarily distributed by the prevailing westerly winds of the region.

There is always the possibility in this connection that it is not distribution about centres at all which we see. The centres of infection are not always easy to determine. Having been determined, the question rises, are the nearer surely infected trees, *i. e.*, those producing spores, the result of infection by spores which were produced on the original tree? In the majority of cases the writer thinks not, but rather that they were infected before the supposed centre of infection had reached the point of producing spores. This seems the more plausible when badly infected, isolated trees are found with no other chestnuts within one hundred feet and those that are nearest apparently sound.

Petersham is in a transitional forest region where the northern pine overlaps the southern New England sprout-hardwood region. The types are usually distinct. Thus, there is an excellent opportunity to study chestnut in a variety of surroundings as regards type and to see if trees in one type seem more immune to the disease than those in another. Chestnut, of the forest trees, is only exceeded in abundance by white pine and red maple. It occurs on any well-drained soil, either in stands, largely of sprout origin, or at the other extreme, isolated in the open pasture land which is slowly seeding in to pine or even in stands of ninety per cent pure pine. The sprout stands may be of widely varying mixtures of hardwood and chestnut, or they may contain chestnut up to sixty per cent of the stand by number or a much larger percentage of the dominant trees. Trees and stands of all ages up to eighty years are represented and scattered individuals may be considerably older.

There appeared to be no relation between susceptibility to attack and the types in which chestnut occurred. Trees with fully developed fruiting bodies were found under all the conditions in

which chestnut grows in the region, — in the open pastures; along roadsides; isolated trees in pine stands; isolated trees in stands of red maple, gray birch, and aspen; in mixtures of red oak, chestnut, ash, and maple; and in stands classified as chestnut slopes. Certainly no type provides immunity from the disease, although the data collected indicates, as will be shown later, that presence in or proximity to certain types tends to increase the liability to infection.

The frequent discovery of dead or badly infected trees in or near stands of pure pine or pine in mixture led to the detailed examination of all the chestnuts over an area where infection had been found by Professor Graves in 1911 and where many trees are now dead or very badly infected. The stand was a sprout-hardwood slope, with easterly aspect, in which chestnut formed thirty per cent to forty per cent of the stand. It was bounded on the north by twenty year pine; on the west by a strip of twenty year pine with open, grassy land beyond over the crest of the hill; at the foot of the slope to the northeast, there was a patch of pine and hemlock and southward, a maple swale followed the brook. Five fifty foot strips were run down this slope, parallel to the north boundary, the first three adjacent to the pine and the last two at intervals of one hundred feet. Every chestnut on these strips was inspected and placed in one of four classes, Class IV to include all apparently uninfected trees. The rest of the data was noted as previously described. The strips are numbered successively from the north at the edge of the pine to the south.

Strip number	1		2		3		4		5	
	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent
Class I	47	*27*	30	*19*	24	*12*	19	*9*	9	*4*
Class II	46	26	50	31	73	38	101	46	71	31
Class III	38	22	46	28	81	42	76	34	76	33
Class IV	44	25	35	22	15	8	25	11	73	32
Totals	175	100	161	100	193	100	221	100	229	100

The progressive decrease in the percentage of surely infected trees as you go further from the pine at the north edge is very striking.

The results shown in Classes II, III, and IV, although somewhat contradictory, are comparatively insignificant, because the large number of spore-producing trees in the stand for the last year or more would be sure to cause recent infection in most of the chestnuts on the area through any agency. Hence, they are of little value as indicating the primary means of distribution to new localities. To further test this same idea, the data from this area were divided into three strips, perpendicular to the first five, so that the first was adjacent to the pine at the top of the slope, the second, along the central portion, and the third, along the foot, next to the hemlock and maple swale. These strips cover approximately one hundred and fifty feet in width.

Strip number	1		2		3	
	Number of Trees	Per cent of total	Number of Trees	Per cent	Number of Trees	Per cent
Class I	61	*17*	20	*8*	51	*17*
Class II	166	47	82	32	114	37
Class III	91	26	124	48	101	33
Class IV	35	10	32	12	41	13
Totals	353	100	258	100	307	100

In this table again, the number and percentage of surely infected trees are greatest in the strips adjacent to the pine or swale.

Outside of this area also, the Class I trees were found most frequently near coniferous stands. Since notes were made on the distance of infected specimens from coniferous stands only in the latter part of the study only sixty-three trees are included in the following table: —

Location		In pure Pine Stands	Within 100′ of Pine	100′–500′ from Pine Stands	500′+ from Pine Stands	Totals
Class I	Number of Trees	4	28	20	11	63
	Per cent of Total	6	44	32	18	100

This data as a whole would seem to show that it is more than mere coincidence that the disease occurs more frequently in or

near coniferous stands. The most plausible and, so far as the writer can see, the only reasonable explanation of such a distribution is by bird agency. It is a well-known fact to any one who has ever watched the habits of birds that they are more abundant on the borders of woods, especially evergreen woods, or where there is a change of type, as at the edge of a swampy tract. If then, both the birds and the disease are more abundant at the edges of coniferous stands where the hardwoods or chestnut adjoin them, and no other agency will account for such a distribution of the disease, why should the two facts not be cause and effect ?

The data on the location of fruiting bodies on the tree as regards height seem to point to the same conclusion. Actual notes taken in the latter part of the field work show that when the infection was still comparatively local on the trees, it usually had started on the main stem, somewhere in the middle third of its height. The writer feels certain that, if further data on this point had been secured, it would have shown the same results. The data secured are as follows: —

Position on Tree	Middle third	Above	Below	On a branch only	Total
Number of cases	28	1	5	3	37
Percent of total	76	3	13	8	100

In three cases, in which the trees were climbed to examine infections which were confined to branches, the fruiting bodies were on the upper sides of the branches only. In only two cases did the infection seem to have started round a wound. These figures again indicate a distribution by birds, and primarily by the creeping birds, such as the creeper, nuthatches, and woodpeckers, which spend most of their time on the trunks and big limbs. Although these birds are permanent residents in Petersham, there is a decided migration of them in spring and fall as those that are residents further north or south pass through. This would explain the rapid spread of the disease over long distances and also its peculiar local distribution.

In order to discover any possible effect of distribution by wind, the groups of sprouts, in which not all of the trees were surely

infected, were considered separately. This furnished data for the following table which show the relative frequency with which the infected sprouts were found in different positions in the groups.

Position in group	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Central
Number of cases	2	4	3	12	6	5	2	4	2

These results surely show that a prevailing southwest or northwest wind is not the prime factor in the distribution of the spores.

The disease is a serious menace to the future production of chestnut in the region. Of about 700 trees examined (counting groups of sprouts as single trees), 122 or seventeen per cent had infection which seemed to be two or more years old; nine or one per cent showed a probable three year old infection. Several trees which were examined fifteen months previously by Professor Graves and considered sound at that time are now badly infected. On the special tract, where the infection was as bad as any that the writer saw, in a stand with a large proportion of chestnut, the results were as follows: —

	Number of Trees	Per cent of total
Dead †	28	3
Class I	129	13
Class II	341	35
Class III	317	32
Class IV	192	20
Totals	979	100

From these figures, it is evident that the chestnut bark disease is a very serious and imminent menace in this region. Estimating conservatively and judging from the fact that trees, dead at present, have not been infected more than three years, thirteen per cent of the trees in this stand will be dead in two years and twenty-five per cent to thirty per cent in three years.

† Dead trees are also included in Class I.

From the foregoing data, it is possible to sum up the following tentative conclusions as to the habits and status of the fungus. It is fully realized that the basis for most of these tentative conclusions is very meager.

1. The disease is well established and widely distributed in the town of Petersham.

2. Sprout or seedling origin has no effect on the susceptibility of chestnut trees to the disease.

3. Proximity to highways and roads has no apparent relation to the infection.

4. The fruiting bodies appear first almost always on the S. or S. W. sides of the trees.

5. Trees over six inches in diameter at breast height are somewhat more resistant to the disease than those below that size.

6. There is no definite direction of spread about centres of infection.

7. The location of infected trees in partially infected groups of sprouts shows that wind is not the prime factor in the distribution of the spores.

8. Dominant trees are as likely if not more likely to be infected than suppressed ones.

9. Lesions usually appear first in the middle third of the main stem.

10. The disease occurs in any type where chestnut forms a part of the stand. Infection is more abundant, however, near the margins of coniferous stands, which indicates that birds may be a very important, if not the primary agent, in its distribution.

11. At the present time, the worst infection seen shows thirteen per cent of the chestnuts badly infected so that they will die in two years.

COLLECTION OF LODGEPOLE PINE SEED ON THE LEADVILLE NATIONAL FOREST

J. Edward Martin, M.F. 1908

Considering the large areas on the Leadville National Forest that have been burnt or cut over, there is no more serious problem confronting the Service than that of reforestation. In most instances, these areas are adjacent to timber line and are above the main bodies of timber so that they do not receive the benefits of the prevailing winds regarding seed dissemination. These areas are potential timber land and at one time supported large bodies of merchantable timber. Owing to the altitude and soil conditions, this land is available for no purpose, excepting at the present time it has a nominal value for grazing.

Many important rivers as the Arkansas, Blue, Middle and South forks of the Platte, together with their principal tributaries, have their origin in the Forest. Practically all of the ranchmen in and adjacent to the Forest, together with those in the valleys below are dependent on the water from these rivers for irrigation purposes. With the agricultural land of the State increasing, water values will also increase in due proportion, as the agricultural value of the land is dependent upon the mountain stream flow. By an extension of forest growth on these denuded areas, a great deal will be accomplished in meeting the above purposes in bringing about a constant and maximum period of water flow when it is most needed for irrigation.

Perhaps the most important question concerning forest extension work is the collection of seed. The extent to which this work is carried on is largely dependent on the supply of seed that is available for this purpose. This problem is one which requires considerable foresight and preparation on the part of the Forest officers. We should always be familiar enough with the Forest, and especially every ranger with his district, to determine whether there is a sufficient crop to make seed collecting practicable.

On the Leadville most attention is given to the collection of lodgepole pine. Although other species as yellow pine, douglas fir, engelmann spruce, etc., are available, we are not so sure of a successful crop. A large annual crop of lodgepole pine seed is conceded a certainty and owing to its wide distribution and accessibility, a large amount of seed can be collected every year. At the high altitudes no species is considered more favorable for reforestation, and from a protective standpoint, it is considered one of our most important trees. Owing to its great variety of uses, it is also an important tree for commercial purposes.

Two years are required for lodgepole pine to mature their cones, consequently, the small green cones that are seen in the spring form the basis upon which to determine the crop expected in the fall. The flowers of the lodgepole pine are orange red in color, and the staminate are in short crowded spikes, while the pistillate are clustered or in pairs on stout stalks. The blossoms of this species are conspicuous in May or June. By July 15, the staminate flowers have withered or disappeared, and the pistillate flowers have begun to develop into growing cones, so that there is no difficulty in determining the crop. By considering the density of the stand, the distribution of the crop, and the area over which the crop appears to be good, we have a basis on which to estimate the amount of seed that will be available.

Prior to 1910, all the seed that was used for reforestation work was sent here from the other Forests. The first extensive seed collecting on the Forest was done in the fall of 1910 when crews were working adjacent to Leadville, Dillon, Buena Vista and Twin Lakes. A total of 678 bushels was collected at a cost of \$1.431 per bushel, or \$4.368 per pound. During the field season of 1911, all the work of collecting this species was concentrated at Dillon. Although all the cost data for last year's collecting is not available at the present time, we are confident that it will be greatly reduced and should not exceed over \$2.50 per pound.

In general seed collecting starts about September 15, although in some instances, collecting might start a little earlier. On this Forest, the last cones are generally secured about November 15. In this locality the length of the cone collecting season is generally determined by climatic conditions.

Cones are generally obtained from squirrel hoards, climbing trees, and lumber cuttings. Only the first two methods have been employed on this Forest.

Squirrel Hoards.—In collecting cones, the greatest success has come through the observation of the squirrels in locating their hoards and obtaining the cones. As these little denizens of the forest use the same locations every year, their hoards are easily recognized by the old scales that are generally heaped around the hoard. These hoards can be classified as buried and exposed.

In the first instance, the cones are found in the old hoards that have been used for several years, and this year's crop is generally buried under the old hulls. They are generally found along old logs, accumulations of poles, and in rock crevices. Another method of burying them is to put from four to six cones in small pockets in the ground or rotten logs. The exposed hoards are found along the underside of logs, poles, rocks, and at times on the top of the ground.

The amount of cones that have been found in hoards run from one to six bushels, while the maximum amount obtained on the Forest from one hoard has been fifteen bushels. In walking through the Forest during the fall, one observes that where squirrels are abundant there is a store of cones around practically every log. With such an abundance of cones available, there is very little likelihood of collectors securing the entire supply.

Climbing Trees.—During the fall of 1910, this method was applied for experimental purposes. One method employed was that the men stood on the ground and collected the cones from the lower branches, while the other consisted in climbing the trees where the tops were heavily laden with cones. The latter can be worked to best advantage by starting at the top and working down, as the clusters on the fruiting branches can be easily seen and any cones that are lodged can be secured. Owing to the great damage that results to the young trees, it would be impracticable to continue this method of collecting cones to any great extent.

The system used in collecting cones, as applied here, can be classified as ranger help and as additional help. Under ranger help is included only those cones that are collected by the rangers working independently and at such times as their other work will

permit. Additional help may be classified (*a*) by paying a contract price per bushel of cones, and (*b*) by paying men working by the day, independently or in parties. During the fall of 1910, when all three methods were used on the Forest, the cost per bushel for collecting cones was $0.706, or $2.33 per pound. During the field season of 1910 the contract price for collecting cones at Dillon was forty-three cents per bushel.

With a supply of cones on hand, the next step is to haul or pack the cones to the treating plant or to the railroad station where they are shipped to the plant. Those that are collected by contract and the ranger force are hauled and packed at no additional expense. In the fall of 1910, cones that were collected at Twin Lakes had to be hauled fifteen miles to Buena Vista, while those collected adjacent to Leadville, had to be hauled six miles to the railroad station and then shipped thirty-six miles to the plant at Buena Vista. The average cost per bushel for hauling cones in 1910 was $0.075, or $.248 per pound. This figure will be reduced to some extent by last fall's work as the collecting was practically all done by contract and ranger labor.

With the active field season brought to a close by climatic conditions, the rangers have ample time to extract the seed from the cones. Two buildings were used for seed extraction in 1910, one at Dillon and the other at Buena Vista. Both buildings were equipped practically the same, except that the ranger at Dillon made a revolving device to shake the seed from the cones.

At Buena Vista a three room house was used, in which two rooms were used for drying and the other for storing the cones. In these two drying rooms were fifty-seven trays, 3×5 feet, covered with one-half inch mesh wire netting. These trays held on the average of one and one-half bushels. At Dillon only one room was used for drying purposes, which held sixty-one trays, 2×4 feet, averaging three-quarters bushel per tray.

The trays in both plant houses are arranged in racks along the sides of the room, being four inches apart, with the upper and lower trays approximately twenty inches from the ceiling and floor respectively. Sheets are then spread on the floor to catch the seed. With the trays properly arranged, a fire is started in the stove. The average temperature at the Dillon plant to open the cones was 120° F., while 100° F. was necessary at Buena

Vista. The average time required to open the cones was four days, this depending to some extent on the weather. The average number of cones extracted per day was ten bushels at Dillon and five bushels at Buena Vista.

With the cones open, it is necessary to remove the seed from the cones. One method employed was to shake the cones in screens by which two men were able to treat twenty bushels in one day. If the cones are entirely open, the seed can be removed in this way, otherwise it is too slow. At the Dillon plant the seed were removed with a revolving churn. The ranger in charge of this work reported that it took from five to twenty minutes to run a bunch of cones through this process, and that he treated forty-five bushels in one day. By this process there is no difficulty in removing the seed from the cones.

With the seed extracted, they are then cleaned by rubbing or beating in sacks, and then running the seed through a fanning mill. This method has proven the most efficient.

The average cost of extracting and cleaning seed was sixty-five cents per bushel, or $1.79 per pound. The extraction and cleaning of last year's crop is not complete at the present time, but we are certain that the cost of 1910 will be reduced.

The seed are then suspended in sacks in a cool dry cellar or attic where they are stored away until spring, when sowing operations begin. Care should always be taken to guard against seed destroying animals and changes in air temperature and air moisture.

Before sowing the seed in large quantities, it is very essential that the seed should be tested to determine its germinative power. Seed testing must be done very carefully to be of any value, and in order that reliable data may be obtained it is necessary to have this work done at the Fremont Experiment Station, where there is special equipment provided for this purpose. The average germination test of all samples of seed collected in 1910 was .666%, while the average number of seed per pound was 70,000. The average test of seed of the 1911 crop, as far as returns have been received, is .661% with the average number of seed per pound 95,000. It has been found that a bushel of cones will yield .33 pound of seed. Approximately 2,100 cones are necessary to produce one pound of seed, while 360 cones are required to make one bushel.

RECONNOISSANCE ON THE TAHOE NATIONAL FOREST

KNOWER MILLS, M.F. 1911

THE aim of the Forest Service is to manage each forest in such a way that its products will, as soon as possible, be made continuously available to the people who need them. In accordance with this purpose reconnoissance work, as a step in the direction of complete working plans, is chiefly concentrated at present on Forests where a large amount of timber sale business is expected. The Tahoe National Forest in California is one of these.

During the summer of 1911 the writer was employed in reconnoissance work on the Tahoe. An important part of the work consisted in securing the necessary estimates and maps for one of the largest government timber sales in District 5. The recent change in Forest Service policy with regard to large sales, permitting the disposal of mature timber on a large scale, with permits providing from five to twenty years for the removal of the timber, has resulted in several sales for large amounts. Few long term sales have hitherto been made on account of the difficulty of foretelling stumpage rates which would be fair to the Government and to the purchaser throughout the life of the contract. It is worth noting that the sale of 73,000,000 feet of timber which was recently concluded on this Forest initiates a new method of establishing future stumpage rates, providing for readjustment at five year intervals, to conform with current lumber values.

The Tahoe Forest is situated on both sides of the main divide of the Sierras in California and Nevada. It has a gross area of 1,272,470 acres, but is so much broken up by patented lands, as a result of the grants of alternate sections to the Southern Pacific Railroad, that the amount of actual forest land within the forest boundaries is only about one-half the gross area. This " checkerboard " condition, which complicates timber sale policy and grazing management to a considerable extent, is felt strongly in

reconnoissance, since it requires the running of a large amount of "dead line" between the isolated subdivisions of government land and makes it possible to cover only a relatively limited area from one camp.

The summer work was in two main forest types — the jeffrey pine type, which is characteristic of the high plateau region on the east slope of the Sierra Nevada Mountains at this latitude, and the red fir type, which is found on the upper slopes and ridges of the main divide of the Sierras. These include several more or less definite sub-types in which subordinate species enter into the composition of the stand. Work was also done in two other pure types — lodgepole pine and black hemlock, which are less important commercially.

Jeffrey Pine Type. — The general altitudinal range of this type is from 5,000 to 7,500 feet on south exposures, and from 5,000 to 6,200 feet on north slopes. The essential trees are jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies concolor*). Other less important species of occasional occurrence are sugar pine (*Pinus lambertiana*), incense cedar (*Libocedrus decurrens*), western juniper (*Juniperus occidentalis*), red fir (*Abies magnifica*), and lodgepole pine (*Pinus contorta*). In a few localities western yellow pine occurs with jeffrey pine. From the forester's standpoint, these two species are practically identical.

Two sub-types, pure jeffrey pine and jeffrey pine-white fir can be distinguished. The former occurs on south exposures and at lowest elevations in dry situations. The stand is a very open, old selection forest composed mainly of over-mature and mature trees with a smaller proportion of the younger age classes. The density of the stand is determined by the root struggle for moisture rather than by competition of the crowns for light. The average stand is about 10,000 B. F. per acre. Growth is very slow. Forest growth on the east slope of the Sierras presents a strong contrast with growth on the west slope.

The jeffrey pine-white fir sub-type occupies a transition zone between the pure jeffrey pine sub-type and the red fir, or subalpine type. It reaches best development on north slopes between 5,000 and 6,200 feet altitude. A typical proportion of species in this type is sixty per cent jeffrey pine and forty per cent white fir.

The density here is often determined by crown competition for light rather than by root struggle for moisture. The average yield is about 18,000 B. F. per acre. Reproduction is mainly fir, occurring in groups beneath the large trees; jeffrey pine reproduction, on the other hand, comes in only in openings but it outgrows fir in the seedling stage.

Management in the jeffrey pine type aims to favor jeffrey pine within the limits of the best growth. A modified shelter-wood system is used with the aim of providing adequate pine reproduction, conserving the factors of site and securing a second cut in thirty years. It is not advisable to open up the stand heavily on account of deficient soil moisture and the competition of brush.

Red Fir Type. — Red fir is the chief species. The general altitudinal range of the type is from 7,500 feet on south exposures, and from 6,500 feet on north slopes up to the summits. Although red fir sometimes occurs pure, it is more often associated with white pine (*Pinus monticola*), white fir, black hemlock (*Tsuga mertensiana*) and lodgepole pine, in various mixtures and proportions, forming several more or less definite sub-types. White fir generally predominates at the lower limits of the type but is less numerous at higher altitudes. The stand is a selection forest, with a tendency toward grouping of age classes. The average stand is about 25,000 B. F. per acre, but the yield shows a wide variation in accordance with local conditions. The maximum stand is about 125,000 B. F. Such large yields occur, however, only under the most favorable conditions and on restricted areas. Red fir reaches its best development on deep moist soil in sheltered situations.

The chief consideration in marking is protection of the remaining stand from damage by wind. A group selection system is used in management, favoring red fir. Watershed protection is an important consideration in marking.

Both the red and white firs are of great value as pulp material. A sale of 5,500 cords of these two species was made last year on this Forest to a company which uses 28,000 cords of red and white fir timber per year. The products are a high grade of wrapping paper and tissue paper.

Lodgepole Pine Type.—This type, which generally consists of pure lodgepole pine, is governed in distribution by soil moisture. It occurs only around the edges of mountain meadows, along the banks of streams, and in moist pockets in the side hills. The average stand is about 5,000 B. F. per acre. Mixtures of lodgepole pine with red fir, white fir and hemlock are frequently found.

Black Hemlock Type.— Pure hemlock occurs only on high peaks at altitudes from 7,500 feet to the summits. The average stand is 12,000 B. F. to the acre. The type is at present of little value commercially but is valuable as a protection forest.

The Forests of the West Slope.— Forest conditions on the west slope at elevations from 3,000 to 5,000 feet, where reconnoissance is being carried on this winter, offer a strong contrast to conditions on the east slope where the above described types are found. The west slope of the Sierras in the region covered by the Tahoe National Forest is the richest gold producing locality in the state. The mining boom which followed the discovery of gold in 1849 was followed by a period of settlement which brought with it the exploitation of a large amount of the virgin yellow pine, sugar pine, douglas fir, white fir, and incense cedar, which originally covered a large part of this country.

Reproduction, chiefly of yellow pine, came in quickly on the cut-over areas and growth is extremely rapid on account of favorable soil and moisture conditions. Consequently we have a combination of virgin stands of high yield with many scattered second growth even-aged stands from thirty-five to fifty years old which compare favorably in density, quality, and rate of growth with the even-aged douglas fir stands on the western foothills of the Cascade Mountains in Washington and Oregon.

The party last season consisted of four field assistants, a packer-cook and a forest assistant. A second forest assistant and a ranger, who were engaged in timber sale work and silvical studies, joined the party at intervals. The method used was the strip system which was followed throughout the district. A strip one chain wide in dense timber and two chains wide in more open stands was run through the centre of each "forty." This gives an estimate based upon five or ten per cent of the area. In most cases distances could be obtained with sufficient accuracy by pacing but the chain

was frequently used in locating corners and running difficult lines. The Forest Service standard staff compass was employed. The compassman ran out the line for each strip, tallied the distance covered, took necessary field notes, mapped topography and types on a scale of four inches to the mile, and noted elevations, which he obtained from aneroid readings. The estimator recorded the D B H and the number of sixteen foot logs of all the trees on the strip, and took silvical notes.

Frequent checks of diameter and height estimates were made by means of the hypsometer and diameter tape. For each forty the per cent of cull for defects in each species was noted and a correction factor was applied when, in the estimator's judgment, the strip did not represent average conditions on the forty.

All trees twelve inches and over in diameter were included in the estimate of the total stand. Trees six to twelve inches D B H were tallied by diameter classes and recorded by number of each species. Trees between six inches D B H and five feet in height were described as saplings; trees below five feet in height were classed as seedlings. These two classes were estimated by the total number per acre and the percentage of each species. The silvical data noted for each forty covered the following points: rock, soil, ground cover, underbrush, condition of timber (in detail by species), average age, factors aiding or hindering logging, adaptability of land.

When a section was completed, a brief forest description was written, summarizing the points on the forty sheets, and including a description of the timber by species, according to size, quality, and condition. No attempt was made to work up the estimates in the field, but the map work was kept up-to-date. The types were colored on the maps in accordance with a legend used throughout the district. From these section maps township maps on the scale of two inches to the mile were later made in the office.

The work was entirely in surveyed land and in most cases little difficulty was experienced in finding the old Land Office corners, most of which were set from thirty-five to fifty years ago. Copies of the original field notes were of great value in retracing the work of the old surveyors. As a rule only two miles of exterior lines were run and blazed for each section estimated. These

were sufficient to establish points to which the strips could be tied. All forest boundary lines within reach of camp were run out, blazed, and posted.

The total area covered was 28,500 acres; the cost per acre was \$0.057. The amount estimated was 269,155,000 B. F.; the cost per M. was \$0.0067.

THE ART OF PACING

E. I. Terry, B.S.F. 1907

Pacing is one of the roughest methods of measuring distance and cannot be used where a high degree of accuracy is required, but within its limitations it has a wide and extremely serviceable field of usefulness for many kinds of forest work. With a hand or staff compass the woodsman may employ it to advantage in finding section corners or other marks from known points, in tracing old lines and in cruising timber. It is the cheapest and quickest method of making forest and topographic maps, and it is the mainstay of reconnoissance work on the National Forests. The older method of running strip surveys by dragging a chain attached to the compassman's belt has been almost entirely superseded by pacing. It is therefore important, in fact often essential, for the student of forestry to become proficient in the art of pacing. To do this he must have much practice, but there are certain underlying principles which one must understand and apply in order to do consistently accurate work.

For one thing, it is much better and easier to count every *double pace*, — that is, every time the same foot is put forward — than it is to count " with both feet " as most novices and even some experienced pacers do. Our word pace is derived from the Latin *passus*, and that itself meant a double pace. A thousand *passus* made the Roman mile, which was approximately 5000 feet, so the average double pace of the Roman soldier was about five feet. In counting paces with a tally-register — to which I will refer later — it is much easier to record double than single paces.

Again, most beginners try to take an artificial step, such as a three-foot stride. That is exactly the wrong way to pace. The right way is to determine the length of one's natural stride by pacing several times over a measured line which should be at least a quarter of a mile in length. Pacing between section-corners where the lines are clearly blazed and the corners are known to be

correctly set, affords the best practice. For example, if a man finds that he takes, on the average, 1000 double paces to the mile, the length of his double pace is 5.28 feet. Then, to find the distance in feet between any two points which he has paced off, he will multiply the number of paces by that figure. But in calculating the area of large tracts in acres, the foot is a very inconvenient unit of measurement. We should here use the Gunter's chain, as does the Government Land Office in all its surveys. Ten square chains equaling one acre, it is a very simple matter, if the dimensions of a tract have been obtained in chains, to find the acreage. The woodsman therefore should determine his average stride in terms of chains, or the number of paces that he takes to one chain.

But, having determined the length of his stride on level ground, there are a number of modifying factors which one must consider in standardizing his pace. The length of one's stride varies according to the rate at which he travels, — it is longer the more rapidly he walks. One should endeavor to pace at a uniform rate, which rate should not be too fast; he should take a pace in the morning which he can maintain throughout the day. Ordinarily, on comparatively level ground, the rate should not exceed that of three miles an hour.

The slope of the ground is an important factor. A man's natural stride is longer on level ground than in either going up or down hill, and somewhat shorter in ascending than in descending the same slope. In Professor Cary's "Manual for Northern Woodsmen," the results of one extensive test are tabulated, which shows that the length of step ascending a 30° slope is almost exactly half of what it is on the level. A man should, therefore, determine his length of pace on slopes of different degrees as well as on level ground. In practice, it is sufficiently accurate if one determines his pace for what may be roughly classed as gentle, medium, and steep slopes. In my own case, for example, I take on level ground 960 double paces to the mile, or twelve to a chain. On slopes averaging 10° to 15°, I take fifteen paces to a chain, on slopes of 20° to 25°, eighteen paces, and on slopes of 30° or more, twenty-one to twenty-five paces. In hilly country, it is easy to find slopes varying from gentle to steep (or lines of different grade may be laid

out on one steep slope), which will hold a *uniform* grade for a horizontal distance of at least a few chains. On such slopes one should measure accurately as long a line as he can lay off up to, say, five chains, and then by pacing back and forth a number of times, determine his average number of paces to the chain, ascending and descending, for the three classes of slope. He can then compare these results with his length of pace on the level, and thus find out how many paces to allow — or how often to "drop" a pace — in going up or down slopes of different gradient. Otherwise, his allowance for slope will be mere guesswork.

One's physical condition also affects the length of his pace. His stride will be shorter when he is tired than when fresh unless he consciously forces himself to greater exertion. In changing one's field of work from a certain region to another of decidedly different topography — as in going from a level to a mountainous country — he will generally find that he needs considerable practice in order to adjust his pace to the new conditions.

For counting paces or keeping track of the distance travelled, pedometers are, especially in mountainous country, worthless. The most satisfactory instrument is the hand tally-register, or "clicker," which registers up to 1000 and may be set back to zero at any time. Each double pace can be easily registered with this machine. In allowing for slope the extra paces should be dropped at regular intervals, for instance, — if a man takes twelve paces to the chain on level ground and is going up a slope that requires fifteen, he drops, or fails to register, every fourth pace; for a slope requiring eighteen paces to the chain, every third pace; and for twenty-four paces, every other pace. At the end of a mile, his register will always show the number of paces that he takes to cover that distance on level ground.

Another method of recording the distance travelled, which has some obvious advantages in map-making and reconnoissance work, is to register each chain. Using this method, one who takes twelve double paces on the level will count his paces mentally and click the register at the end of each twelfth pace; when he comes to a gentle slope, he will count fourteen or fifteen paces before registering, and on steeper slopes eighteen, twenty, or twenty-four paces, as the grade requires. In this way he can readily

make allowance for slopes of different gradient and can quickly and easily locate his position on the map. At the end of one mile his register will always show the number eighty.

In covering large acres by means of compass and pacing, the work should of course be tied in at frequent intervals to points that have been accurately located. Reconnoissance crews, when working in unsectionized country, have found it sufficient to run transit or compass lines two miles apart, the reconnoissance men pacing back and forth between these lines and generally running their lines one-quarter of a mile apart. This makes only eighteen miles of surveyed line to a township.

Pacing as a means of measuring distance has doubtless never been developed to its full capacity, but it has probably been most fully developed in the reconnoissance work on the National Forests. In Johnson's "Surveying," the statement is made that when a man's pace has been standardized and he walks at a constant rate, distances can be determined "to within two per cent of the truth." The author probably referred to open and comparatively level ground, yet I believe that in much of the reconnoissance work in the Rocky Mountain forests the error has not exceeded that. Day after day I have seen some of the best pacers in our reconnoissance crews run the two miles between surveyed lines, offset a quarter-mile and run back, and as a rule check up within six or eight rods, and they would often come much closer. So important is the method in much of our present-day work that I think it is not an overstatement to say that a man cannot be a good American forester unless he is a good pacer — he certainly will not make a good reconnoissance man.

SOME ORIGINAL DATA ON WATERFLOW AND FORESTS

H. O. Cook, M.F. 1907

Some time ago, I came into the possession of some data that I hoped would add perhaps to our knowledge of the effect of forests on waterflow, from the statistical standpoint. Data of this description are so scarce in this country that I considered that any which promised results should be worked up, no matter how incomplete it might be.

The city of Fall River takes its water from a large pond, some three miles in length and a mile wide, called North Watuppa Pond. Owing to certain legal restrictions, which it is not necessary here to describe, they are obliged to let a certain percentage of the waterflow through a weir into South Watuppa Pond, a body of water which is used by the mill interests of the city as a reservoir. In 1899 the Water Board of the City commenced an extensive investigation, the purpose of which was to determine the total amount of water which each year is delivered to the mills, the amount used by the city through its mains, the amount lost by evaporation, the amount supplied to the pond through direct precipitation, and the amount supplied to the pond by the streams emptying into it. This investigation covered three years and the results were very interesting. They published the data and conclusions in 1902 as a *Report of the Reservoir Commission*, by Arthur T. Safford, consulting engineer. To obtain part of their necessary data they built weirs at the mouths of the various brooks entering Watuppa Pond, and at these weirs took daily measurements of the waterflow for three years, 1899, 1900, 1901. It is these weir measurements that furnish the waterflow data.

In the spring of 1908, the Massachusetts State Forester's office made a forest working plan for the 5,000 acres of land included in the watershed of North Watuppa Pond, and as a necessary part of the working plan we made a forest map of the watershed. From this forest map we derive the necessary data for the forest

area and types of forest land on the eight brook watersheds. Although six years elapsed between the collection of the two classes of data, due allowance has been made on the forest areas for woodland cut in the intervening time.

In the large table the daily waterflow for three years has been combined and averaged for each month. Then each of these figures has been reduced or measured by a factor which would make the watershed of each brook equal to one square mile. In the second column we have expressed in percentage the departure of the monthly flow from the average flow of the twelve months. The departures from the mean give a better means of comparison than the figures of actual flow. We include also a table of rainfall for the same three years.

Description of Watersheds

South Nat Brook

Watershed, 105 acres. Woodland, 25%.

Although only one-quarter of the watershed of this brook is forested it is in this section that it has its source. The forest is of large hardwoods growing on a moist and almost swampy flat. The entire watershed is very level and the brook flows for about four-fifths of its course through level meadows and mowings before emptying into the pond. The soil is deep and loamy.

Terry Brook

Watershed, 140 acres. Woodland, 65%.

This brook flows through a level watershed its course being bordered on both sides by maple swamp. Of the forest land about one-third is maple swamp. The soil is shallow and rocky and many out-cropping ledges testify to the nearness of the underlying rock.

Queen Gutter Brook

Area, 402 acres. Woodland, 95%.

This watershed is long and narrow and has a well defined slope. The soil is gravelly and deep. The bed of the brook is swampy and wooded with red maple. The greater part of the wooded land, however, consists of sprout oak and some pine.

North Nat Brook

Watershed, 135 acres. Woodland, 18%.

This brook has its source on a small shallow pond and flows for its entire course through open meadow land. The forest land of sprout oak is in a far corner of the watershed where it can have but little influence on the flow of the brook. The topography is flat and the soil deep.

Run Brook

Watershed, 125 acres. Forest area, 100%.

This watershed has a well defined slope and a rocky gravelly soil. The forest is sprout hardwoods much of which has been cut off. The course of the brook is short and it takes its rise in outcropping springs situated not far above the weir.

Ralph Brook

Watershed, 215 acres. Forest area, 40%.

The watershed of this brook is generally flat with a deep loamy soil. The brook has most of its course through open land. It has one source in a maple swamp and another in a small pond hole in the midst of some large hardwoods. The conditions of the watershed resemble greatly those of South Nat Brook, but the flow is much more regular.

Blossom Brook

Watershed, 1,372 acres. Woodland, 85%.

Not only is this watershed thoroughly forested but nearly one-half of it is swamp, so that conditions would seem ideal for a regular flow of the stream; but Mr. Stafford suspects that much of the precipitation on this watershed passes into the pond underground and that the weir measurements only represent a part of the actual run-off, especially in dry weather.

Conclusions

Although the flow of all these brooks is so extremely irregular as to allow little choice, I have classified those which seem to be somewhat more regular than the others as follows: —

Irregular are South Nat, Terry, and North Nat, and Queen Gutter, and regular flowing are, Run, Ralph, and Blossom. Of the irregular brooks North and South Nat brooks have very little forest on their watersheds, whereas Terry and Queen Gutter are well forested. Queen Gutter has a well defined slope on its watershed, whereas the watersheds of the other brooks are quite flat.

In case of the regular flowing brooks the watersheds of Run and Blossom brooks, are entirely forested whereas Ralph Brook is only one-half forested. Blossom and Run brooks have a considerable area of swamp on which to depend for storage but Run brook has no swamp land in its watershed.

The reader can easily see from the nature of the above facts that it would be exceedingly hazardous to venture to draw any conclusions from them. A different story would probably be the result of these measurements had they been taken in a mountainous country with a rocky slope, but in a country of comparatively slight slopes and a deep gravelly soil the effect of a forest cover would not seem to be very large in the run-off of streams.

It is interesting to note how much more consistent, from month to month, is the flow of the streams than the precipitation. An excess of seventeen per cent in the rainfall of September does not seem to have had much effect on the run-off of that month or the next.

AVERAGE FLOW PER DAY AND PER SQUARE MILE OF WATERSHED OF THE BROOKS ON THE NORTH WATUPPA WATERSHED SHOWING MONTHLY DEPARTURES FROM MEAN MONTHLY FLOW MEASUREMENTS OF THREE YEARS

Months	All Brooks	Depart.	South Nat	Depart.	Terry	Depart.	Queen Cutter		North Nat		Run		Blossom		Ralph		Rainfall	
	1000 gals.	Per cent	1000 gals.	Per cent		Per cent		Per cent		Per cent		Per cent		Per cent		Per cent	Inches	Per cent
January	1,349	+33	2,652	+174	2,216	+60	1,017	+25	935	+82	861	+25	1,413	+25	872	+24	4.12	+11
February	1,555	+49	1,524	+57	2,247	+62	1,181	+44	625	+21	813	+19	1,614	+43	1,055	+50	3.30	−11
March	3,057	+201	2,925	+202	4,399	+217	2,691	+231	1,262	+145	1,758	+156	3,292	+192	1,803	+155	6.00	+61
April	2,256	+122	1,716	+77	3,012	+118	2,077	+155	1,221	+137	1,852	+170	2,448	+117	1,767	+150	4.22	+13
May	1,968	+94	1,642	+70	2,274	+64	1,741	+114	828	+61	1,461	+112	2,307	+105	1,300	+84	5.06	+36
June	332	−67	184	−81	644	−54	413	−50	188	−63	482	−30	649	−42	340	−51	2.40	−36
July	160	−84	20	−98	47	−97	61	−92	61	−88	83	−88	236	−80	80	−89	2.96	−20
August	54	−95	1	−100	0	−100	1	−100	6	−98	26	−96	82	−93	14	−98	2.04	−45
September	90	−91	88	−90	14	−99	20	−96	53	−90	46	−93	135	−90	59	−91	4.36	+17
October	185	−82	200	−79	60	−95	15	−97	171	−66	146	−80	264	−76	178	−74	3.33	−11
November	280	−72	201	−79	332	−76	55	−93	155	−70	225	−67	346	−70	221	−68	2.77	−23
December	750	−26	1,194	+23	1,227	−11	517	−36	652	+27	490	−28	744	−34	787	+12	4.12	+10
Mean	1,015		968		1,386		813		514		687		1,126		705		3.72	

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